Analysis on Current Situation of Yunnan's Demand Response and Research on Improvement Methods

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Abstract. At present, the implementation of DSM fails to effectively alleviate the seasonal and periodic power shortage in Yunnan Province, and it is still dominated by the active regulation of power grid companies, lacking of market-oriented mechanism. Based on the experience of Jiangsu and Shandong Province in demand response, this paper puts forward several problems in Yunnan Province, such as the lack of basis for formulating demand response subsidy price, the platform construction has not yet realized the power data access of main power users, the implementation of demand response is imperfect and lacks market-oriented mechanism. On this basis, improvement methods are proposed, including distinguishing the capital sources of peak shaving and valley filling demand response, promoting the construction, development and operation and maintenance of the demand response platform of Yunnan energy investment group, and actively organizing enterprises to apply for DSM demonstration enterprises and products in the industrial field.

1. Introduction
In 2015, the release of "several opinions on further deepening the power system reform" clearly pointed out that it is necessary to actively carry out power demand side management, so as to relieve the pressure of peak load regulation, and ensure the safe and reliable operation of power grid. Since the national comprehensive construction of power demand response pilot cities was carried out in China, the implementation of demand response has been expanding. Beijing, Jiangsu, Shanghai, Guangdong, Tianjin, Henan, Zhejiang and Jiangxi have been successfully implemented [1-4].

As a typical giant receiving end power grid, it is difficult to construct Beijing power grid due to its special position as the capital. Therefore, in order to alleviate the pressure of power grid peak operation, Beijing promotes the implementation of pilot power demand response, so as to achieve the purpose of market-oriented adjustment of power load and reduction of peak valley difference. At 11:00-12:00 on August 12, 2015, Beijing implemented the first city wide power demand response work, and the implementation effect was good. With the large-scale integration of clean energy power generation into the power grid and the construction of trans-regional UHV transmission channels, the power supply side adjustability of power system is gradually decreased. In order to adapt to the increasing urban electricity demand and peak valley difference, Jiangsu has carried out a large-scale power demand response practice, and gradually strengthened demand side management through market-oriented means, and also implemented "peak shaving" demand response for the first time in August 2015. With the increasingly
prominent load characteristics of the receiving end of Shanghai power grid, the peak valley difference increases yearly. Therefore, as a pilot city, Shanghai implemented "peak shaving" demand response as early as August 2014, and gradually carried out a series of attempts such as virtual power plant. As the first batch of pilot projects, Foshan City of Guangdong province carried out "peak shaving" demand response as early as July 2015, and has been actively exploring the integration of demand side response and power market construction [5-9].

With the rapid growth of new energy power generation and power transmission outside the province, the proportion of coal-fired power continues to decrease, and the structural contradiction of power supply in Yunnan Province is increasingly prominent. In addition, hydropower aluminum, hydropower silicon and other power consumption projects are put into operation, leading to the rapid growth of power consumption. On this basis, Yunnan Province begins to attach importance to the development of demand response. In accordance with the requirements of “notice on promoting supply side structural reform and improving DSM under new situation”, in order to implement the "power demand side management measures" and promote the whole society to use electricity scientifically, economically, safely and intelligently, Yunnan Energy Bureau has already issued a series of documents, such as "letter of Yunnan Provincial Energy Bureau on Soliciting Opinions on carrying out electric power demand response market pilot work", "notice of Yunnan Provincial Energy Bureau on doing a good job in power demand side management in 2019", etc., to promote the implementation of Yunnan demand side response work. However, the implementation of DSM in Yunnan Province has failed to effectively alleviate the seasonal and periodic power shortage in Yunnan Province. At present, Yunnan Province still arranges the orderly use of electricity by power users through the traditional mandatory management measures such as power restriction and emergency switching off, which lacks market-oriented mechanism and is difficult to mobilize the enthusiasm of market participants [10-11]. Therefore, this paper will draw lessons from Jiangsu and other typical provinces and cities to analyse the development of demand response in Yunnan, and put forward improvement methods from three aspects: demand response subsidy mechanism, demand response platform construction, and demand response implementation.

2. Materials and Methods
Firstly, using content analysis method, aiming at the current situation of seasonal and periodic power shortage in Yunnan Province, the demand response subsidy mechanism, the construction of demand response platform and the implementation of demand response in Jiangsu and Shandong are summarized. On this basis, through the experience summary method, combined with the demand response development in Jiangsu and Shandong, the current situation of demand response in Yunnan is analysed and the problems in demand response subsidy mechanism, demand response platform construction and demand response implementation are further stated. Considering the current problems of Yunnan demand response, such as the lack of basis for formulating demand response subsidy price, the construction of demand response platform has not yet realized the power data access of main power users, the implementation of demand response is imperfect and lacks market-oriented mechanism, the corresponding improvement methods are proposed.

3. Results & Discussion

3.1. Development of demand response in typical provinces and cities in China

3.1.1. Jiangsu
In terms of demand response subsidy mechanism, Jiangsu implements special subsidies for demand response by means of verifying peak tariff revenue and increasing electricity charges. Regarding subsidy standard, for the "peak shaving" demand response, the compensation standard for the invitation response time not longer than 60 minutes is 10 yuan / kW · time; for the invitation response time length from 60 to 120 minutes, the compensation standard is 12 yuan / kW · time; for the invitation response time longer
than 120 minutes, the compensation standard is 15 yuan / kW · time. For the "valley filling" demand response, the subsidy standard is 5 yuan / kW · time in valley time and 8 yuan / kW · time in level time. In addition, the compensation amount is also related to the advance notice time of demand response. The shorter the advance notice time is, the larger the response speed coefficient is, while the response speed coefficient of real-time demand response is 3.

In terms of demand response platform construction, Jiangsu Power Grid's large-scale source grid load friendly interactive system was put into trial operation in June 2016, which is the first national grid system protection project put into operation nationwide. By 2020, it achieves 40,000 households and 12 million kW second level precision control capability. The system centralizes and accurately real-time controls massive interruptible loads to realize friendly interaction among the power supply, power grid and load. In November 2017, Jiangsu Electric Power Co., Ltd. officially put a friendly interactive demand response platform based on flexible load regulation into operation. The platform brings the load with certain energy storage and regulation capacity into the platform as adjustable capacity for management, and its business model gradually changes from forced power cut-off and power restriction to flexible regulation. Also, the platform promotes the development of China's demand response to the stage of normalization and non-perception flexible regulation. In addition, the power management system and smart home management system can be employed as support platform to complete real-time demand response with the demand response centre.

In terms of demand response implementation, "peak shaving" demand response was implemented in August 2015 in Jiangsu. All 557 users and 8 load integrators applied for demand response were invited. 513 users and 8 integrators actually participated in the demand response, and the invited load was 1.6274 million KW, while the actual response reduced the load by 1.6577 million kW. The successful implementation of demand response indicates that Jiangsu's load management has changed from administrative means of orderly power consumption to market-oriented demand response. In July 2019, Jiangsu Province once set a record of cutting 4.02 million kilowatts of load. Under the condition that the environmental comfort is not affected, through intelligent matching low energy consumption strategy operation, the central air conditioning host system, circulation system and terminal operation mode are accurately adjusted, so as to reduce the power load of air conditioning in a short time, and cooperate with the orderly peak shaving of power grid [12-13].

3.1.2. Shandong

In terms of demand response subsidy mechanism, power demand response compensation costs are temporarily from the capital space formed by grid companies participating in the pilot cross provincial renewable energy spot market. The electricity demand response subsidy is directly cashed out to the users in the form of electricity fee deduction. The consumers acting by the power sales company will get the compensation according to the actual response of a single user, and the sharing proportion between the power sales company and the power users shall be determined through negotiation. Demand response in Shandong is in the initial stage of development and "peak cutting" and "valley filling" demand response refers to the experience of Jiangsu. Concretely, the upper limit of 30 yuan / kW · year is implemented, and the participation in demand response is at least 8 times a year. The price ceiling to form demand response clearing price is also adopted.

In terms of demand response platform construction, Shandong reconstructed the power demand side management platform according to the actual business needs in 2017 to serve the demand side management business. The platform inherits and upgrades the core functions of the original DSM platform, discards redundant functions, and provides macro-economic analysis, energy efficiency services, orderly power consumption, demand response and direct transaction support services for government departments, power grid enterprises, integrated energy service companies, power sales companies, power customers and other customers through the integration of dispatching automation system, power consumption information acquisition system and power trading centre system data. The whole system is divided into portal website and management system. The portal website provides the public with popularization of power demand side knowledge and information inquiry services. The
management system provides power demand side related information services for the government, power supply companies and power consumption enterprises.

In terms of demand response implementation, Shandong implemented "valley filling" demand response from 12:00 to 13:00 on December 20, 2018. 264 users were invited and 555800 kW of load responded, among which 187 industrial users responded 431900 kW, and 14 non-industrial users responded 71000 kW. On December 27, 2018, peak shaving and valley filling were implemented on the same day. From 12:00 to 13:00, the maximum response load of valley filling was 316000 kW and the response load of peak shaving at night was 617000 kW. From 14:00 to 16:00 on August 8, 2019, the real-time "peak shaving" demand response was carried out by sending response instructions to 4 enterprises and 2 power sales companies with the ability of rapid load regulation, and the response load was 101800kW during the process. Among them, State Grid Shandong Integrated Energy Service Co., Ltd. participated in the demand response as a power sales company, and invited 6 proxy users, which actually reduced the load of 50200 kW. The successful implementation of demand response marks the expansion of service field and market in Shandong.

3.2. Current situation and problems of demand response in Yunnan

3.2.1. Current situation of demand response in Yunnan

In terms of demand response subsidy mechanism, Kunming Electric Power Trading Centre takes 150% of the response amount determined by the annual response plan as the response demand in the first ten days of May every year. The trading centre is listed to the market entities through the power trading platform, and the power consumers or power selling companies conduct bidding transactions. The response volume and compensation price shall be declared for the transaction, and the maximum compensation price for 1 kW load response shall not exceed 20 yuan temporarily. If the same market entity has multiple electricity marketing account numbers, the market entity should report the same compensation price. Kunming Electric Power Trading Centre will clear the compensation price from low to high and declaration time from front to back. The clearing price is the transaction price of the last 1kW response. The number of the participation of users and power sales companies should be at least eight responses per year. Those who respond less than eight times will be compensated according to the percentage of response times, and those who respond less than half of the responses will be treated as breach of contract and will not be compensated.

In terms of demand response platform construction, Yunnan power demand side management platform has been basically completed in June 2018. The platform realizes the functions of portal operation, power online monitoring, registration and access, and plans to access the national power demand side management platform timely. At this stage, Yunnan draws lessons from the advanced experience of Jiangsu, Shandong, Shanghai, Ningxia, Inner Mongolia, Henan and other provinces and cities, breaks through the bottleneck of capital and technology, effectively integrates resources, and issues the "notice on accelerating the intelligent power management", in order to make the power data of more than 1000 industrial enterprises in the province connected to the platform, and to realize the demand response function.

In terms of demand response implementation, there are no enterprises participating in demand response in Yunnan. In addition, Yunnan Province requires the municipal power supply bureaus to prepare, adjust and implement three schemes, namely, the over planned power consumption limit list, the emergency power cut-off sequence table, as well as the implementation scheme of low-frequency and low-voltage load reduction of power grid in 2020. The power distribution situation of Yunnan power grid over planned power consumption and power restriction due to accident is shown in Table 1. At present, only four enterprises in Yunnan Province, including Chihong Zinc Germanium Company, Conch Cement Baoshan Company, Yuntianhua Tian'an Company and Yuntianhua Shuifu Company, have become the national power demand side management demonstration enterprises in the industrial field, and the power consumption data of these four enterprises have not been connected to the provincial power demand side management platform.
Table.1 The power distribution situation of Yunnan power grid over planned power consumption and power restriction due to accident

| Power supply bureau | Power beyond the planned power consumption limit | Power for emergency power cut-off | Expected peak load | Power supply bureau | Power beyond the planned power consumption limit | Power for emergency power cut-off | Expected peak load |
|---------------------|-------------------------------------------------|----------------------------------|-------------------|---------------------|-------------------------------------------------|----------------------------------|-------------------|
| Kunming             | 1082                                            | 1488                             | 5600              | Qujing              | 913                                             | 1277                             | 4120              |
| Honghe              | 540                                             | 795                              | 2700              | Yuxi                | 422                                             | 636                              | 1930              |
| Chuxiong            | 176                                             | 283                              | 980               | Dali                | 371                                             | 556                              | 1855              |
| Zhaotong            | 462                                             | 693                              | 2310              | Puer                | 97                                              | 162                              | 648               |
| Lincang             | 86                                              | 142                              | 570               | Xishuangbanna       | 85                                              | 141                              | 565               |
| Wenshan             | 556                                             | 834                              | 2780              | Baoshan             | 126                                             | 210                              | 842               |
| Lijiang             | 93                                              | 155                              | 620               | Dehong              | 158                                             | 262                              | 1050              |
| Nujiang             | 81                                              | 135                              | 540               | Diqing              | 48                                              | 80                               | 320               |
|                     |                                                 |                                  |                   | Ruili               | 29                                              | 44                               | 147               |
| Total of the whole network |                                  |                                  |                   |                     | Power beyond the planned power consumption limit |                                  | 5325              |
|                     |                                                 |                                  |                   |                     | Power for emergency power cut-off                |                                  | 7893              |
|                     |                                                 |                                  |                   |                     | Expected peak load                               | 26198                            |                   |

3.2.2. Analysis of the problems in Yunnan's demand response

(1) Demand response subsidy mechanism

The current demand response in Jiangsu implements demand response subsidy by means of verifying peak electricity price revenue and increasing electricity charge. The demand response is divided into peak cutting type and valley filling type, whose fund source is relatively reasonable. Shandong's demand response compensation fee is temporarily from the capital space expenditure formed by the power grid company's participation in the pilot project of trans-provincial renewable energy spot market. Referring to Jiangsu, the demand response is divided into peak cutting type and valley filling type to formulate the demand response subsidy standard. However, the price of demand response subsidy in Yunnan lacks basis. The source of funds is not clear, which does not conform to the principle of "who benefits, who pays" in the demand response work [14].

(2) Construction of demand response platform

Jiangsu has built a large-scale source grid load friendly interaction system and a demand response friendly interaction platform based on flexible load regulation. In order to complete real-time demand response with the demand response centre, the power management system and smart home management system are also constructed. In 2017, according to the actual business needs, Shandong reconstructed the DSM platform to service DSM business. However, in the process of Yunnan demand response, the demand response platform is still unable to access the power consumption data of industrial enterprises. As an information carrier to realize the data support and load analysis of power demand side management, if power demand side management can not realize the access of power consumption data of main power users, it is difficult to realize on-line monitoring and data analysis of electric energy, meeting the requirements of power demand response [15].

(3) Demand response implementation

The "peak shaving" demand response implemented in August 2015 in Jiangsu marks the transformation of Jiangsu load management from administrative orderly power consumption means to market-oriented demand response. Then, in July 2019, a record load reduction of 4.02 million kW was set. Shandong province implemented "valley filling" demand response on December 20, 2018, peak shaving and valley filling on the same day on December 27, 2018, and then carried out real-time "peak shaving" demand response on August 8, 2019. State Grid Shandong Integrated Energy Service Co., Ltd. also participated in the demand response as a power sales company. Different from the gradual change from orderly power consumption to market-oriented in typical provinces and cities, Yunnan Province still arranges orderly power consumption of power users through traditional mandatory management measures such as peak load shifting, peak avoidance, power restriction and emergency switching off,
which is dominated by the active regulation of power grid companies and lacks market-oriented mechanism. Moreover, the power consumption data of only four national industrial DSM demonstration enterprises have not been connected to the provincial DSM platform, and the implementation progress of demand response is inefficient.

3.3. Improvement methods of Yunnan demand response

3.3.1. Demand response subsidy mechanism
Referring to Jiangsu’s demand response subsidy mechanism, based on the principle of "who benefits, who pays" in the demand response work, this paper distinguishes the "peak cutting" demand response fund source from the "valley filling" demand response fund source, and puts forward the improvement methods of demand response subsidy mechanism.

In the peak load period, in order to maintain the balance of power supply and demand, some power users who continue to use electricity during this period are charged with peak electricity price to compensate the power users who are willing to participate in the "peak cutting" demand response and reduce load, that is, to collect funds from the power users who benefit during the peak period, so as to compensate the power users who sacrifice their power demand. Therefore, in view of the "peak shaving" demand response, the scheme of charging seasonal peak price to all industrial and commercial users is adopted.

In the low load period, in order to maintain the balance of power supply and demand, some power users increase the electricity load during the valley filling period, which ensures the increase of power generation capacity of power generation enterprises during the valley filling period, and reduces the start-up and shutdown of units and the abandonment of wind and solar power. The beneficiary of "valley filling" demand response is the power generation enterprises, which need to collect funds according to the grid electricity of power generation enterprises during the valley filling period, so as to compensate the power users who effectively implement the "valley filling" demand response.

3.3.2. Construction of demand response platform
In order to speed up the dynamic monitoring of power consumption data of industrial enterprises, timely access to Yunnan public electric energy service management platform, and get through the physical connection among the platform, the power grid dispatching and power trading centre, efforts should be made to promote the construction, development, operation and maintenance of the demand response platform of Yunnan energy investment group, and necessary human, material and financial resources should be invested to ensure the construction of the platform. Also, the platform should meet the functional requirements of power data access, online monitoring and demand response of industrial enterprises above the provincial scale. Meanwhile, we should pay attention to the relevant rules of Yunnan power demand side management platform to cooperate with the implementation of pilot power demand response, and accelerate the increase of the number of enterprises connected to the platform until it meets the requirements of demand response implementation.

3.3.3. Demand response implementation
First of all, efforts should be made to promote the power consumption data of Chihong Zinc Germanium Company, Conch Cement Baoshan Company, Yuntianhua Tianan Company and Yuntianhua Shuifu Company to access to the provincial power demand side management platform. Meanwhile, enterprises should be actively organized to apply for DSM demonstration enterprises and products in the industrial field, so as to continuously improve the DSM level of enterprises.

On this basis, it is suggested to strongly cultivate the power service industry. One of the main purposes of DSM is to promote the transformation of power selling enterprises to integrated energy service providers, and cultivate the power service industry. At present, most of the power sales enterprises have single profit model, so it is urgent to promote the power sales enterprises to change their business mode, guide their electricity sales agents to realize on-line monitoring of electric energy,
master the power consumption data of users in real time, and access to the provincial platform, so as to continuously improve the accuracy of electricity market-oriented transactions and avoid deviation assessment. Based on the analysis of user electricity consumption data, it is suggested to promote the integration of electricity sales business development and power demand side management, and provide comprehensive energy services, value-added services and demand response services.

4. Conclusions
At present, the implementation of DSM in Yunnan Province has failed to effectively alleviate the seasonal and periodic power shortage in Yunnan Province. Yunnan Province still arranges orderly power consumption of power users through traditional mandatory management measures such as power restriction and emergency switching off, which is mainly based on the active regulation of power grid companies and lack in market-oriented mechanism. On this basis, from three aspects of demand response subsidy mechanism, demand response platform construction and demand response implementation, this paper combs the development experience of demand response in Jiangsu and Shandong. In view of the existing problems, such as the lack of basis for formulating demand response subsidy price, the platform construction has not yet realized the power consumption data access of main power users, the implementation of demand response is imperfect and lacks market-oriented mechanism, some improvement methods are proposed, including distinguishing the capital sources of peak shaving and valley filling demand response, promoting the construction, development, operation and maintenance of the demand response platform of Yunnan energy investment group, actively organizing enterprises to apply for DSM demonstration enterprises and products in the industrial field, and strongly cultivating the power service industry.

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