Feasibility Study on Optimization of Electricity Consumption Mode for Agricultural Irrigation Project in Gansu Province

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Abstract. Due to the lack of water resources and the cross subsidy of electricity price, the agricultural irrigation electricity in Gansu Province has been characterized by extensive management and strong seasonality for a long time, which has brought difficulties to the regulation and management of the power grid, increased the peak load of the power grid, and caused great pressure to the safety and supply of the power grid. This paper first introduces the current situation of Gansu agricultural irrigation project and the peak regulation capacity of Gansu power grid, analyzes the existing problems, and combines the requirements of the " Gansu Electric Power Auxiliary Service Market Operation Rules (Trial) " document. From the perspective of optimal utilization of water resources and power grid supply, the typical case analysis of Gansu agricultural irrigation project participating in the demand side response market is carried out, and the feasibility of optimizing the power consumption mode of agricultural irrigation project is discussed. It provides new ideas for solving the low utilization rate of agricultural irrigation resources and alleviating the pressure of power grid supply, and contributes to the power industry for rural revitalization.

Keywords: Agricultural irrigation project; Optimization of electricity consumption; Demand side response market; Optimal utilization of water resources; Peak load regulation capability of the power grid; Electricity price

1 Introduction

Due to the lack of water resources and the cross-subsidy of electricity price, the agricultural irrigation electricity in Gansu Province has long been characterized by extensive management and strong seasonality, which brings difficulties to the regulation and management of the power grid, greatly increases the peak load of the power grid, and is not conducive to the economic operation of the power grid. This paper discusses the new mode of farmers' irrigation and electricity consumption from three aspects: water resources utilization, electricity price subsidy and power grid supply guarantee, and puts forward relevant suggestions, so as to provide solutions to the problem of the

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inverted price of agricultural irrigation and drainage electricity price and the unit purchase cost of power grid company, and contribute to the power industry for rural revitalization.

1.1 Present Situation of Agricultural Irrigation and Drainage in Gansu

Gansu Province, agricultural drainage and irrigation power sub-surface water irrigation and groundwater irrigation, the main irrigation equipment is a large pump. There are 21 large-scale irrigation projects with high head of 10,000 mu in the province, including large-scale irrigation projects such as Jingtai Chuan Electricity Irrigation Project, Xingbao Chuan Electricity Irrigation Project and Jinghui Electricity Irrigation Project. In addition to large-scale electric irrigation projects, there are many to solve the irrigation of farmland along the Yellow River and the drought areas of rural drinking water for humans and animals and the construction of small-scale irrigation and rural pumping wells irrigation, this part of the load is mainly characterized by the distribution of a wide range of capacity is not large, the amount of electricity for irrigation of a single project is relatively small.

Gansu Province is located in China's northwest inland, long and narrow, harsh natural conditions, scarce water resources, arid climate with little rain and windy, irrigated agriculture in the province has a pivotal position[1]. Gansu agricultural irrigation load is divided into spring irrigation and winter irrigation, spring irrigation generally occurs in April-August throughout the year, winter irrigation generally occurs in September-November throughout the year, the size of the load is affected by weather changes fluctuations. As the peak periods of agricultural irrigation and power consumption in Gansu Province are generally from 7:00-9:00 and 17:00-23:00, the time period is the peak period of daily grid load.

1.2 The Current Situation of Peak Regulation Capacity of Gansu Power Grid

Gansu Province, due to its unique resource endowment, new energy installed capacity and power generation are at the forefront of the country, providing an excellent demonstration for the Party Central Committee to promote carbon peak carbon neutral. According to the statistics of State Grid Gansu Electric Power Company, in the first nine months of this year, Gansu new energy added 9,825,100 kilowatts of grid-connected capacity. As of the end of September, Gansu Province, new energy installed capacity of 45.3 million kilowatts, in the province's total installed capacity of power supply accounted for 58.07%, a record high. At present, the scale of renewable energy in Gansu Province in the province's total installed capacity of power supply accounted for more than 70%. However, due to insufficient space in the province to consume the market, the system peak capacity is limited, poor transmission capacity and other factors, Gansu has become one of the most serious areas of the country abandoned wind and light.

1.3 Current Situation of Agricultural Irrigation and Drainage, High Lift Irrigation Electricity Price

Agricultural irrigation tariff refers to the irrigation and flooding electricity for agricultural production services, as well as rural drinking water safety project water supply electricity. At present, there is no policy of optimizing peak and valley time-sharing tariffs for agricultural irrigation and high-lift irrigation, which is priced uniformly for the whole 24-hour period and is the lowest price for electricity in Gansu Province, and the specific price of electricity sold is shown in Table 1.

Table 1. Agricultural electricity price table of Gansu province

Electricity classification			voltage level	Household electricity price (yuan / kWh)		
				peak	Flat section	low ebb
agricultural production electricity power usage			≤1kV	0.6714	0.4489	0.2265
			1-10kV	0.6564	0.4389	0.2215
			≥35kV	0.6414	0.4289	0.2165
including	Agricultural irrigation and drainage electricity		≤1kV		0.2325	
			1-10kV		0.2275	
			≥35kV		0.2225	
	High lift irrigation	Groundwater pumping	≥101m		0.1905	
		Surface water pumping irrigation	101-200m		0.1205	
			201-300m		0.1105	
			≥300m		0.0905	

Because there is no approved transmission and distribution price for agricultural irrigation and drainage, it is impossible to participate in the purchase of market electricity price. At present, the principle of ' optimal generation and optimal supply ' is adopted for electricity price matching. As the main body of power purchase, the power grid company participates in market-oriented power purchase, preferentially matches the minimum electricity price, and exceeds or balances the approved electricity price to share the profits and losses by industrial and commercial users.

1.4 Gansu Electric Power Auxiliary Service Market Operation Related Situation

On December 30, 2022, the Gansu Energy Regulatory Office issued the "Gansu Electricity Auxiliary Service Market Operation Rules (Trial)" (Gan Supervision Energy Market [2022] No. 238), which provides a basis for further tapping into the regulation capacity of conventional power sources, energy storage, customer loads and other aspects, enhancing the flexibility and security and stability of the Gansu power system, and gradually promoting the auxiliary service market costs on the two sides of

power generation and users to be fairly and reasonably shared. Provides a basis for fair and reasonable sharing of auxiliary services market costs in the power generation and user sides. According to the content of the document, Gansu Agricultural Irrigation and Storage Project can be used as a market-based power user, by changing its inherent power consumption pattern, reducing the peak load on the basis of normal power consumption (the daily peak load of the power grid is generally in the two periods of 7:00-9:00 and 17:00-23:00), and participating in the peak shaving response regulation by bidding in the form of quoted price, and also obtaining a certain amount of peak shaving revenue in accordance with the peak shaving response price (0-1 yuan per kWh). To obtain a certain peak shaving revenue, to promote the balance of power sup-ply and demand transactions for Gansu agricultural irrigation and storage projects to participate in the demand-side response market transactions opened a new way of thinking[2].

2 Existing Problems

First, Because there is no policy to optimize the peak-valley time-of-use electricity price, and it is the lowest electricity price in Gansu Province, the cost of water resources exploitation using electric energy as power is low, which leads to excessive exploitation of groundwater resources. The phenomenon of excessive exploitation of groundwater by agricultural electric irrigation and ' flood irriga-tion ' in wasteland is not uncommon. Due to a large number of over-exploitation of groundwater, the groundwater level continues to decline and desertification intensifies, which leads to the overall decline of groundwater level in Hexi Corridor of Gansu Province, the increase of salinity, the deterioration of water quality, the dry tide of tidal flats, and the desertification of land, threatening the survival and development of local people and the health of the ecosystem in Hexi Corridor and even parts of northern China.

Second, the province's basic irrigation projects built in the 1950s to 1990s, part of the original irrigation district electromechanical irrigation equipment has not been replaced or transformed, its overall effectiveness and ability to meet the needs of modern agricultural development.

Third, part of the irrigation area in the summer irrigation peak (late May ~ July) there will be a shortage of water, can not meet the irrigation needs of farmers, on the other hand, due to irrigation canals water damage, water transmission capacity is insufficient, the pumping station to lift the water after the rainfall and so on resulting in the existence of a large number of water abandonment, resulting in large amounts of wasted power losses to a certain extent, for example, Jingdian II Gulang irrigation district irrigation intervals subject to the Minqin water transfer channel water transfer capacity constraints, the year produces Abandoned water about 22.84 million cubic meters [3].

Fourth, with the new energy installed in Gansu increasing, new energy big time corresponds to the current flat section and low valley, is not conducive to guide the user in the new energy big time to increase electricity consumption, can not reduce the pressure of new energy consumption.

Fifthly, The pumping irrigation project mostly adopts the ' flood irrigation ' method for farmland irrigation. The daily pumping period of the pumping station is full-time (24-hour uninterrupted load) pumping, which further compresses the peak-shaving space of the power grid during peak hours. Moreover, in recent years, the installed capacity of new energy in Gansu has been increasing, and the period of new energy development corresponds to the current flat section and trough. The current way of pumping electricity has increased the pressure on new energy consumption.

3 Research Ideas on Optimization of Power Consumption Mode of Agricultural Irrigation Project

In accordance with the country to promote the implementation of the rural revitalization strategy, a new round of western development to form a new pattern, Gansu Province, the province of high-quality development of water conservancy, "four grasping a through" and other development requirements, in order to further give play to the benefits of the agricultural irrigation project, and vigorously develop the facilities of agriculture, to consolidate and enhance the results of the poverty alleviation efforts, and to promote the overall economic and social development as a guide, to provide the following ideas.

3.1 New Storage Tank to Ease the Pressure of Supply

Due to the climatic conditions of high evaporation and low rainfall in Northwest China, crops have the characteristics of large water demand and long irrigation cycle, and the pumping station irrigation system often appears in the high water period, the amount of water raised by the pumping station is larger than the amount of water used in agricultural irrigation, resulting in water wastage, and in the dry season, the amount of water raised by the pumping station does not satisfy the amount of water used in agricultural irrigation, and there is an imbalance between the pumping station water and the actual water use. Through the high terrain area in the vicinity of the irrigation project, select the appropriate location to build a high level storage tank, or in the irrigation project at all levels of the pumping station near the appropriate place to build a storage tank, so that the water transfer level by level [4]. Both methods can not affect the premise of irrigation water, in the grid load in the trough time to withdraw water, stored in the reservoir, the grid load peak time to reduce the withdrawal of irrigation power, so as to alleviate the new energy consumption and power supply pressure.

3.2 Promotion of Water-Saving Irrigation to help Farmers Increase Production and Income

First, to fight for national high-standard farmland construction subsidies to promote the construction of high-standard basic farmland. Guided by special funds for land remediation, aggregating relevant agriculture-related funds, focusing on inputs, guid-

ing and regulating the participation of social forces, adopting comprehensive remediation measures for fields, water, roads, forests and villages, adapting to local conditions, strengthening the construction of water conservancy facilities, raising the level of informationization of farmland, and popularizing high-efficiency planting techniques, so as to improve the quality and efficiency of farmland. Second, promote water and fertilizer integration technology. Through soil testing and crop demand analysis, the soil nutrient content and crop demand for nutrients and water are accurately assessed, and combined with modern technology, remote monitoring is carried out to realize precise control and accurate supply of irrigation and fertilization.

3.3 Building Solar Pumping Station to Subsidize the Income of Agricultural Irrigation Project

In the context of "Shaguo desert" base construction, make full use of the abundant solar energy resources, combined with the irrigation project renewal and renovation plan, the construction of solar energy irrigation station. Gansu irrigation area light conditions are generally better, with the advantage of playing photovoltaic power generation, through the "light to make up for the water" can be realized in the irrigation period of water supply electricity self-sufficiency, saving electricity costs, but also in the non-irrigation period of power generation and grid, and further subsidies to agricultural irrigation revenue.

3.4 Shaping the 'heavenly Lake ' Landscape to Boost the Development of Rural Tourism Industry

Relying on existing or new agricultural irrigation and storage projects, combined with rural rivers and lakes, countryside trails and rural water conservancy facilities and other features, the storage pond and the surrounding environment for beautification, while supporting the improvement of the stacks, viewing platforms and other hardware facilities, to create the "Alpine Pools" artificial land-scape, and promote the development of rural tourism industry.

3.5 The Implementation of Agricultural Irrigation and Drainage Load Demand Side Management, Promote Energy Saving

The main content of demand side management is to promote the use of reactive local compensation technology for agricultural irrigation motors. The power load of agricultural irrigation is seasonal, the irrigation time is concentrated, the utilization rate is low, and the natural power factor is low. The use of reactive power local compensation technology for agricultural irrigation motors can improve the power factor, reduce the reactive power loss of lines and transformers, and produce obvious power-saving effects. In order to reduce the burden of farmers ' electricity bills, reduce cross-subsidies, and achieve a win-win situation for farmers, power users and power companies.

4 Typical Case Analysis of Agricultural Irrigation Project Participating in Demand Side Response Market

4.1 Jingtaichuan Electric Power Lift Irrigation Phase II Project

engineering situations. Jingtai Sichuan Power Irrigation and Lifting Phase II Project (hereinafter referred to as "Jingdian Phase II") has 30 pumping stations, with a total installed capacity of 180,800 kilowatts, and develops 500,000 mu of farmland irrigation in Jingtai and Gulang counties, and a total installed capacity of 17,545 kilowatts of pumping stations in Gulang Irrigation District in Jingdian Phase II, with no complete storage project in the whole irrigation area. The number of days of annual irrigation lifting is 215 days, 24 hours of water lifting per day, and 5,160 hours of water lifting per year. According to relevant information, Jingdian Phase II project plans to build a new storage pool with a total volume of 14 million cubic meters [5], after the pool storage can be solved the shortage of water in the irrigation area during the year.

Participating in demand side response market transaction analysis. If the King Power II storage tank project can participate in 2-4 hours a day demand side response market transactions, assuming a total of 215 days a year full-time water and participate in the peak shaving response, the daily peak period to participate in the demand side response market transactions can cut the load of about 180,000 kilowatts per day, each year, can reduce the pressure on the supply of power supply of about 77.4-154.8 million kilowatt-hours, and at the same time according to the latest document of the operation rules of the Gansu Provincial Electricity Auxiliary Service Market, the price of the peak shaving response to the upper and lower limits of the 0-1 yuan per kWh of electricity, which can bring about the peak shaving income of the most years of about 154.8 million yuan [6].

4.2 Huining County Jinghui Electric Irrigation Project

engineering situations. Huining County Jinghui Electric Irrigation Project pumping station with a total installed capacity of 95,780,000 kilowatts, pump house head mainly for more than 270 meters, the whole irrigation area without storage project, the total irrigated area of 1.5 million acres, the number of days of lifting irrigation for the year is 151 days, lifting water for 24 hours a day, lifting water for 3,624 hours a year. According to the relevant information, in 2022, Jinghui project lifting total power of 99.51 million kilowatt-hours, the total amount of water lifted 86.73 million cubic meters, 8.366 million yuan of electricity deposits.

Participating in demand side response market transaction analysis. If the Jinghui electric irrigation project in Huining County to build storage tanks, with reference to the experience of similar projects in the province according to 45-60 yuan per cubic meter unit cost estimates (excluding ancillary engineering costs and other costs), and assuming that there are a total of 151 days in a year, the full power of the full time to lift the water and to participate in the response to the peak shaving, and at the same time, according to the rules for the operation of the Gansu Provincial Electricity Auxiliary Services Market, the peak shaving response price upper and lower limits of 0-1

yuan per kWh of electricity, the storage project to participate in the demand-side response to the market transactions related to the situation in Table 2, it can be seen that after the completion of the peak shaving project will be far greater than the peak shaving benefit after the completion of the project cost of its construction.

Table 2. List of Participation of Jinghui Electric Irrigation and Storage Project in Demand Side Response Market Transactions

serial number	Storage project capacity(10^3m^3)	project investment calculation(10^4)	Guaranteed water supply duration(h)	Maximum participation time in Daily demand response transactions(h)	Daily load sidereduction capability(10^4kW)	Maximum power reduction throughout the year(10^4kWh)	Maximum peak-cutting income(10^4)
1	8	480	2	2		2869	2869
2	16	960	4	4		5738	5738
3	24	1440	6	6	9.58	8607	8607
4	32	1920	8	8		11476	11476
5	96	5760	24	8		11476	11476

5 Conclusion

Currently, agricultural irrigation in Gansu Province, there are problems such as over-exploitation of water resources, "big water irrigation" management sloppiness, old irrigation equipment, water shortages and water abandonment, etc. In order to further promote the benign development of agricultural irrigation projects in Gansu Province, it is recommended to carry out the construction of agri-cultural irrigation storage ponds, accelerate the construction of high-standard farmland and water-saving irrigation technology transformation, create "Alpine Tianchi" landscape integration project, carry out agricultural irrigation storage project to participate in demand-side response market trading feasibility study [7], etc., to further optimize the Gansu agricultural irrigation project electricity mode, improve the actual income of the agricultural irrigation project, increase the peak capacity of the power grid, help farmers to increase production and income, and to achieve the mutual benefit of the agricultural irrigation project, the power grid enterprise, the farmers win-win situation.To this end, the following suggestions are proposed for power supply enterprises, irrigation projects, and farmers:

Power supply enterprises: Strive to implement the national fiscal transfer payment policy for agricultural drainage and irrigation electricity in Gansu Province. The national fiscal will directly supplement the electricity consumption of agricultural drainage and irrigation users, increase the price of agricultural drainage and irrigation electricity, establish a time of use electricity price mechanism, such as providing electricity subsidies for water storage dam projects and high-level water storage tank (reservoir) irrigation projects, guiding users to use staggered electricity, freeing up electricity price space to alleviate related electricity price conflicts.

Irrigation project: It is recommended to promote the government to build high-level water reservoirs (reservoirs) in high terrain areas near the irrigation project under the background of the "dual carbon" and rural revitalization policies. The power supply company should support the construction of the power grid, and according to the peak shaving demand of the power grid, timely water storage should be carried out to achieve dynamic balance.

Farmers: Scientifically guide farmers to adjust their planting structure according to local conditions. Optimize the planting of economic crops based on the impact of water resources, climate, and other conditions in each region, and select low water and drought tolerant economic crops for planting. Guide farmers to adjust their farming habits, scientifically and reasonably carry out farming, encourage farmers to carry out water-saving irrigation, reduce resource waste, and improve the utilization rate of water and electricity resources.

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