Design of Long-term and Medium-term Trading Model under Multi-energy Coupling

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ABSTRACT: Integrated energy service is a new industry with broad prospects in China. It is the energy industry from the vertical extension of the industrial chain to the horizontal interconnection. However, there are few studies on the domestic market trading mode. In view of this, this paper proposes a multi-energy coupled trading mode of cold, heat, electricity and gas in the medium and long-term multi-energy flow market.

1. Introduction

The technology of integrated energy system has been paid attention by all countries in the world. Different countries often formulate their own integrated energy development strategies according to their own needs and characteristics. German Smart Watts project achieves optimal energy output and contract establishment at the business level, and comprehensive information sharing through the Internet at the information level [1]. Open Utility in the UK sells surplus electricity to nearby business users through end-to-end transactions [2]. Under the framework of the Horizon 2020 Plan, the EU conducts a comprehensive study on the business model, market model and energy trading mode of end-to-end transactions [3]. Tokyo Electric Power provides customers with a variety of price schemes and optimal combination of electrical equipment schemes to help customers improve equipment and production processes [4].

China's comprehensive energy started late, and the relevant demonstration projects are limited. Feng Lihong [5] summarizes seven business models based on the case of integrated energy systems at home and abroad. Literature [6-7] designed a comprehensive energy management scheme with multi-time scales such as day-ahead, time-ahead and real-time for the park. Literature [8] proposes a market trading framework for integrated energy parks, which is dominated by energy operators and participated by distributed photovoltaic power generation and electric vehicle charging agents.

In view of the current situation and trend of China's power market construction, this paper proposes a long-term and medium-term cold, heat, electricity and gas multi-energy coupled transaction model under the framework of integrated energy system, which provides the construction ideas and models for China's integrated energy services.
2. Multi-energy Flow Market Under Energy Internet

2.1 Trading Subjects Participating in Multipurpose Flow Market
The multi-energy flow market under the energy Internet is composed of electricity, gas, cold, heat and other energy transactions. The main trading bodies include thermal power enterprises (thermal power plants), renewable energy generation enterprises, natural gas suppliers, power companies, property companies, technology companies, service companies and other third-party companies.

2.2 Trading Characteristics of Multi-energy Flow Market

(1) Diversification of trading subjects
With the deepening of energy Internet theory research and the promotion of pilot work, as well as the continuous opening of power selling side, distributed generation, energy storage, microgrid, park, EV, flexible load and so on can participate in market transactions to varying degrees.

(2) Diversification of commodities traded
Flexible resources will become an important commodity, such as peak shaving and frequency modulation resources on power generation side, adjustable demand side resources on power side, energy storage and charging and discharging of electric vehicles.

(3) Decentralization of trading decisions
The multi-energy flow market under the energy Internet can realize the integration of production, supply and marketing of local areas through advanced Internet technology and distributed generation, energy storage and other technologies, so that the region can achieve self-balance and Pareto optimum through self-regulation.

(4) The instantaneity of trading time
The transaction cycle changes from fixed-cycle transaction to user-initiated instant transaction. In the future, the speed of supply of goods and services will be one of the key factors to determine whether a transaction can be reached.

3. Design of Cold, Heat, Electric and Gas Multi-energy Coupling Trading Model in Medium-term Multi-energy Flow Market

3.1 Multi-energy Flow Trading with Energy Storage Participation
Operators will integrate many types of distributed energy storage devices in residential, building and household application scenarios, such as electricity storage, heat storage, cold storage, clean fuel storage and other decentralized, redundant and performance-limited energy storage batteries, uninterrupted power supply, electric vehicle charging and discharging piles, and build a database of energy storage facilities. The storage of distributed energy storage equipment will be managed and operated through the Internet. At the same time, energy storage cloud platform is constructed to realize modular design, standardized access, hierarchical utilization and network management of energy storage equipment, and to support free and flexible energy trading.

3.2 Intelligent Charging and Discharging Mode of Electric Vehicle and Grid Coordination
Firstly, based on the historical power consumption data, the main peak-shaving and frequency-modulation time nodes in the future are predicted. According to the principle of maximizing economic benefits, fully mobilizing energy storage equipment to charge and discharge, and reserving sufficient resources for peak shaving and frequency modulation. Besides, in the period of no frequency modulation demand in power grid, according to the principle of "low charge and high amplification", energy storage equipment is arranged to operate to obtain the benefit of electricity price difference. When facing the demand of power grid frequency modulation, sufficient resources of peak-load and frequency-modulation are reserved in advance. In the period of insufficient frequency modulation resources, energy storage resources are released to the maximum capacity, and ancillary
service fees of frequency modulation are charged.

3.3 Energy Internet Micro-Balance System and Operation Mode
The decentralized micro-balanced business model of energy Internet includes the following aspects:

(1) Energy self-supply. On the basis of promoting distributed generation and distributed energy storage, all kinds of users can meet their own energy demand. If there is surplus, the distribution of distributed energy nodes can be carried out locally.

(2) Energy generation of labor. The middleman collects the energy demand of all kinds of users and accepts and quotes them in a unified way. The middleman establishes an generation of labor relationship with a number of energy providers, and the latter produces the corresponding energy and provides it to users.

(3) Energy Group Purchase. Users gather purchasing power by group buying to enhance their position in the market game. At the same time, it provides a platform for energy suppliers to conduct bulk sales, so as to facilitate their unified control.

(4) Energy barreling. Standardization and normalization of energy services can include standardized energy storage equipment, standardized energy supply curve, energy supply format contract, etc.

3.4 Retail Package Design for Different Customer Demands
According to the different needs of industrial and commercial customers, integrated energy service companies can design different service schemes. Aiming at energy-saving demand, Integrated Energy Services (IES) can provide customers with the best energy supply combination scheme covering electricity, gas and heating, and provide the optimal combination of various electricity price schemes and electrical equipment schemes to help customers improve equipment and production process. To meet the demand of emission reduction, comprehensive energy service company can launch a service called "renewable energy premium". The electricity in this service is completely provided by new energy power plants, and the profits obtained are used to subsidize new energy enterprises. In view of the high reliability demand, IES can provide all-round services including renewable energy power generation, communication, heating, water supply, architectural design, construction and maintenance, so as to improve the reliability of enterprise power consumption and energy operation and maintenance management level. In order to reduce the initial investment demand, integrated energy service companies can promote "energy service providers" services, customers can obtain electricity, gas supply, as well as electrified heat pumps, substation equipment and other energy-efficient equipment and its operation and maintenance services. The initial investment of customers is zero, and the cost will be amortized to the equipment in the form of service fees Life cycle.

4. Design of Cool, Heat, Electricity and Gas Multi-Energy Coupled Trading Model in Long-term Multi-energy Flow Market

4.1 Gas-Electric Coupled Market Based on Time-Sharing Marginal Node Price
Integrated market model based on marginal node price: accurately reflect the real-time change of supply-demand relationship, allow demand to respond to price time-sharing, improve market efficiency and reliability; It reflects the severity of network congestion, provides incentive mechanism for congestion management, reflects the impact of load on network loss, and provides additional signals for transmission costs. If the natural gas market draws lessons from these experiences and obtains the marginal node gas price (GLMP) from the constraints of natural gas reservoir and natural gas network, it will provide price signals reflecting the transportation cost and physical capacity of pipelines for the main body of the natural gas market. Time-sharing GLMP will take full account of the fast fluctuating demand of electricity market and help to change the lack of real-time response and congestion management in natural gas market. In addition, the natural gas load demand has the implementation basis of providing demand response bidding, and the demand response from the
natural gas load side will effectively alleviate the peak gas load and reduce the uncertainty of obtaining fuel for gas generating units. In addition, nodal electricity price and nodal gas price can also provide key information for coordination between markets.

By analogy with the structure and mechanism of electricity market, a natural gas reservoir is established to settle accounts for both buyers and sellers in natural gas market, and a liquidation model of natural gas market based on LMP is provided.

4.2 Comprehensive Energy Transaction Based on Node Energy Price

For integrated energy systems, it is essential to build a sound internal business model. The energy pricing function of multi-energy flow nodes in the energy internet-oriented integrated energy management system is designed for the business model of integrated energy system. Node energy price function needs to study flexible energy market mechanism. Considering the coupling relationship between different energy market prices under multi-energy flow coupling characteristics, real-time electricity price and heat price can be calculated by joint cost function to encourage users to use energy reasonably and improve resource allocation efficiency.

Under the nodal energy pricing model, the energy consumption cost of each node in the system is firstly determined by calculating, including the energy supply cost, transmission loss cost, network congestion cost and multi-energy coupling conversion cost. Then the energy price of each node is calculated by optimizing, including the energy of different forms of electricity, heat, cold and gas, at different times and at different locations. Source price. Through precise calculation and price signals to guide users' energy use behavior, the overall energy use cost can be reduced by flexible means, which is conducive to the establishment of an internal fair market mechanism.

5. Conclusion

Distributed energy, energy saving and efficiency improvement, the rapid progress of Internet and other technologies, energy customization, energy integration, energy cross-border and other modes continue to innovate, providing more technical means and mode choices for improving the overall efficiency of the energy system. Current research mostly summarizes the development trend and current situation of integrated energy services at home and abroad, and seldom directly puts forward a practical integrated energy services trading model suitable for China's electricity market. In view of this, this paper proposes a medium and long-term cold, heat, electricity and gas multi-energy coupled trading model. The research results can be synthesized for China. The implementation of energy services provides further theoretical support.

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