

# Assessment Model of Customer-Side Integrated Resources Market Transaction Maturity Level

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**Abstract.** This paper analyzes the current situation of customer-side integrated resources market participation, innovatively puts forward the evaluation model of customer-side integrated resources market transaction maturity level, and evaluates the current market transaction situation of customer-side integrated resources from five aspects: market access, trading varieties, market competitiveness, price mechanism and technical support. The research shows that at present, the mechanism of integrated resource participation in the market of the customer side is gradually established, but the maturity of the market transaction mode is still insufficient. This paper further studies and puts forward relevant suggestions to improve the customer-side integrated resource market transaction mode, including the overall market transaction mode and specific suggestions for some kind of resources to participate in the market.

**Keywords.** Electricity market, Customer-side integrated resources, Evaluation model, Maturity level, Transaction mode

## 1. Instruction

Customer-side integrated resources refer to the physical form of distributed power generation, energy storage, adjustable load and other resources that have the ability to interact with the grid and the corresponding grid connection lines, information communications, and production control systems on the power consumption side. According to the technical types of customer-side resources, they can be divided into four categories: distributed power generation, energy storage facilities, adjustable loads, and their aggregates, such as load aggregators, virtual power plants<sup>[1]</sup>.

According to the definition of customer-side integrated resources, there are following characteristics: One is to directly supply power to users or reduce user load, and the flow generally does not pass through the upper-level transformer. The second is the single installed capacity and small response capacity, generally 10MW and below. Third, it is usually connected to the medium and low voltage distribution network, generally 10 (35) kV and below<sup>[2-3]</sup>.

At present, customer-side integrated resources such as distributed power sources, energy storage, and interruptible loads have gradually participated in electricity market. It is necessary to evaluate the maturity of market transaction mode based on the development of customer-side comprehensive resources and electricity market, then propose relevant suggestions for improving the transaction mode.

## **2. Current situation of customer-side integrated resources participating in the market**

### **2.1. Status Quo of distributed power sources participating in the market**

At present, distributed power sources adopt the transaction model of 'users self-use, and the balance is fully connected to the grid'. Grid companies purchase the on-grid power in full at the benchmark price of thermal power, and users receive renewable energy subsidies based on the amount of power generated. Although the country has issued relevant policies for distributed power generation market-based trading, it is still in the pilot stage due to the difficulty of verifying network fees.

### **2.2. Status Quo of Energy Storage's Participation in the Market**

The energy storage on the power supply side can complement the output of thermal power or new energy power generation units, so that these power sources present more stable and controllable external characteristics, which helps to improve the safety and stability of the power system. At present, in addition to some areas where electrochemical energy storage participates in thermal power joint frequency modulation to obtain better expected benefits, other business models and benefit-sharing mechanisms are relatively lacking.

Grid-side energy storage mainly plays the role of system-level peak and frequency regulation and emergency support for large power grids, and the attributes of public products are obvious. Compared with other application areas, grid-side energy storage technology standards are more stringent, and the threshold for R&D, construction, integration, grid connection and operation investment is high. How to channel costs is the most critical issue facing the development of grid-side energy storage. At present, pumped storage can channel costs through a two-part electricity price, while electrochemical energy storage still lacks a corresponding price mechanism.

The user-side energy storage directly faces end users, and has the characteristics of small scale, large quantity, flexible access, and scattered layout. Its profit model such as peak-to-valley spread arbitrage and capacity saving has become clear. After the power spot market is completed in the future, the peak-to-valley price gap on the user side will further expand, release the correct price signal, and guide the user side energy storage to efficiently participate in system adjustment and obtain benefits.

### **2.3. Status Quo of Interruptible Load Participation in the Market**

Under the guidance of national policies, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Henan, Jiangxi, Chongqing and other eight provinces and cities have successively introduced their province's power demand response pilot work plans based on the province's conditions and the balance demand for power and electricity. In 2019 eight demand response pilot provinces have organized and implemented demand response 25 times, reduced peak load of 7.04 million kilowatts and shifted peak power of 81.19 million kilowatt hours; cumulatively increased trough electricity load of 5.44 million kilowatts, and promoted the consumption of 133 million kilowatt hours of new energy. Although the demand response pilot has achieved positive results, the imperfect power market mechanism and imperfect business model have caused the current

demand response pilot to lack sustainable development capabilities and rely heavily on local government financial subsidies.

### 3. Evaluation of the customer-side integrated resources market transaction maturity level

#### 3.1. Evaluation indicators

Combining the development of customer-side integrated resources and the construction of a unified national power market, when evaluating the maturity of the customer-side integrated resource market transaction mode, the main considerations are market access, transaction varieties, market competitiveness, price mechanism and technical support, as shown in Table 1.

**Table 1** Customer-side integrated resources market transaction maturity level evaluation index system

Evaluation dimension	Description
Market Access	The access status of customer-side integrated resources in the wholesale market, including medium and long-term markets and spot markets.
Transaction types	The types of transactions that can be participated in by the customer-side integrated resources, including the auxiliary service market and the electric energy market.
Market Competitiveness	The advantages and disadvantages of competition between customer-side integrated resources and conventional market entities participating in the market.
Price mechanism	The price mechanism and cost compensation mechanism implemented by the customer-side integrated resources to participate in the market.
Technical support	Measurement devices, control systems, trading platforms, settlement systems, etc., for customer-side integrated resources.

#### 3.2. Evaluation results

##### (1) Market access

At present, the electricity market only allows large power users whose voltage level and capacity meet the conditions to participate, and the market subjects are generally ‘electricity producers’ or ‘electricity consumers’, and the market identity of ‘electricity producers and consumers’ is not defined. With the maturity of market mechanisms and technical conditions, the voltage levels and capacity restrictions for market entities' access to the electricity market should be gradually reduced and relaxed, so that more market entities have the qualifications to participate in the electricity market, and at the same time endow customer-side integrated resources the dual authority of ‘power producers’ and ‘power consumers’ in order to maximize its flexibility and improve the efficiency of market operations.

##### (2) Trading varieties

At present, some customer-side integrated resources have participated in the auxiliary service market such as peak shaving and frequency modulation, as well as the medium and long-term power market. In the future, customer-side integrated resources will play a greater role in the auxiliary service market, and at the same time innovate the design of auxiliary service market

transactions. According to resource characteristics, auxiliary services such as reserve capacity, rapid climbing, moment of inertia, etc. are designed. The trading cycle of customer-side integrated resources in the electric energy market has been further shortened, all of which are carried out in short-term or even spot transactions.

### (3) Market competitiveness

The advantage of customer-side integrated resources in the auxiliary service market is that it can quickly and accurately respond to the system's frequency modulation signal, and the ramp rate is high. The disadvantage is that the capacity and power are limited, and the frequency modulation duration is short. The advantage in the electricity energy market is that it can quickly respond to market price signals, use electricity price differences in different time periods for arbitrage; accurately track the electricity trading curve, and reduce deviation settlement fees.

### (4) Price mechanism

At present, the development of customer-side integrated resources is still in its infancy. As the electricity market and ancillary service market are also in the pilot construction phase, the development of customer-side integrated resources lacks an effective economic compensation and profit model. In order to encourage the development of customer-side integrated resources, in its initial stage, appropriate economic compensation mechanisms can be formulated to guide customer-side integrated resources to participate in the power market and ancillary service market, and to encourage rapid start through appropriate additional economic subsidies, tax reductions, and financing support.

### (5) Technical support

At present, the support technology for customer-side integrated resources to participate in the market is gradually being improved, but some customer-side integrated resources' measurement and collection capabilities are insufficient to meet the requirements of real-time curve measurement, data channel, deviation measurement and other information perception capabilities; response time and ramp rate of some subjects, The adjustment range does not meet the minimum requirements of the dispatching agency; and with the extensive participation of the customer-side integrated resources in the market, higher requirements are put forward on the information processing capabilities and settlement system of the trading platform. Based on the above analysis, the current mechanism for customer-side integrated resources to participate in the market is gradually being established, but the maturity of the market transaction model is still insufficient, especially in the three aspects of market access, transaction varieties and price mechanisms. The scoring of each indicator is shown in Figure 1.



**Figure 1** Evaluation results of transaction maturity level of the customer-side integrated resources market transaction

## 4. Suggestions on perfecting the customer-side integrated resources market transaction mode

### 4.1. The overall modes of market transactions

The customer-side integrated resources can take the following three modes to participate in the power market.

#### (1) Participate directly in the wholesale market

Customer-side integrated resources market transaction directly participate in the wholesale market. In the near future, it mainly participates in peak shaving, frequency modulation auxiliary service transactions and short-term electricity energy transactions, and in the long term, it will gradually establish customer-side resources to participate in the electricity market, auxiliary service market and capacity market transaction mechanisms.

#### (2) Aggregate participation in the wholesale market

The virtual power plant operating entity or load integrator can act as an independent market entity to actively participate in the electricity market as an agent for user loads within its own service range. As an intermediary between the wholesale market and the demand-side market, the virtual power plant operator or load integrator can set the time-of-use electricity price, peak electricity price and other price packages in the demand-side market or sign interruptible load and emergency demand response through independent negotiation with the agent user. Wait for demand response contracts to obtain adjustable capacity; obtain electricity and ancillary services through bidding in the wholesale market. The virtual power plant operator or load integrator makes two-way decision-making on the wholesale market and user calls, and then obtains the optimal decision-making plan for participating in the market<sup>[4]</sup>.

#### (3) P2P transaction mode

Relying on the Internet of Energy, based on the power grid and the trading platform as the hub, a platform-type intelligent trading system is built in the active distribution network to carry out direct transactions between distributed power sources and energy storage and power users, and

promote the local consumption of new energy<sup>[5]</sup>. The trading cycle can be monthly, weekly, multi-day, etc.

#### **4.2. Suggestions on various types of resource market transaction modes**

(1) Give full play to the resource optimization and aggregation role of virtual power plants, allowing virtual power plants to participate in the electric energy market and auxiliary service market. The current virtual power plant, as an optimized aggregate of flexible adjustment resources, has participated in the North China peak shaving auxiliary service market and the Shanghai standby peak shaving market. In the future, market access restrictions can be gradually relaxed, allowing virtual power plants with technical conditions to participate in ancillary services such as frequency modulation, and gradually allowing virtual power plants to aggregate flexible price adjustment resources to participate in electricity energy trading in the power spot market.

(2) Give full play to the load-side flexible adjustment capabilities of load aggregators, and improve the design of demand response market mechanisms. At present, my country's demand response mechanism is still in its infancy. The market participants involved in demand response are mainly large industrial power users. The response mechanism is also based on a fixed response method that pre-appoints response time and load reduction. Market-oriented demand response mechanism has not yet been established. In the future, the access standards for demand response can be gradually relaxed, a demand response mechanism for market-based bidding can be established and improved, and the load-side flexible resource aggregation capabilities of load aggregators can be used to promote the participation of qualified aggregators in demand response and encourage load aggregators when conditions are available. Participate in the power spot market in the form of 'negative watt generator sets'.

(3) Give full play to the rapid adjustment ability of energy storage and improve the flexibility of power system operation. Energy storage equipment, as an important flexible adjustment resource of the power system, is mainly used to stabilize the volatility of new energy sources and meet the demand for peak shaving of the system. However, the development of energy storage equipment is limited by construction and operation costs and lacks a market-based compensation mechanism. In the future, with the high proportion of new energy sources, the flexible adjustment capability of the system will face great challenges. The rapid adjustment capability of energy storage should be used, market access standards should be relaxed, and energy storage should be allowed to participate in the spot market and ancillary service market through the spot market. The price signal of energy storage guides energy storage to 'charge low and discharge high', and improve the design of the auxiliary service market mechanism, combined with the characteristics of energy storage to carry out auxiliary service transactions such as backup and rapid climbing.

(4) Establish cost compensation and capacity cost recovery mechanisms for pumped storage, and guide pumped storage to participate in market transactions. At present, pumped storage is mainly based on a two-part electricity price. Part of the economic benefits is obtained through the peak-to-valley price difference of the electricity price, and capacity cost compensation is obtained through the capacity electricity price. In the future, with the establishment of the power spot market and ancillary service market mechanism, pumped storage should be gradually guided to respond to price changes in the spot market, and increase the economic benefits of

pumped storage through 'low storage and high release'. At the same time, establish a sound capacity market mechanism to ensure the fixed cost recovery of pumped storage through the capacity market to ensure the sufficiency of the power system capacity.

## 5. Conclusion

This article innovatively puts forward a maturity evaluation model of the customer-side integrated resources market transaction mode, which evaluates the current market transaction situation of the customer-side integrated resources from five aspects: market access, transaction varieties, market competitiveness, price mechanism and technical support. Studies have shown that the current mechanism for customer-side integrated resources to participate in the market is gradually being established, but the maturity level of the market transaction mode is still insufficient. This article further studies and puts forward relevant suggestions to improve the customer-side integrated resources market transaction modes.

## Acknowledgements

This work is supported by Science and technology project of State Grid Corporation of China "Block chain technology for supporting integrated energy interactive trading services at the customer side"(5100-201957473A-0-0-00).

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