Evaluation model of key driving factors for different types of demand side distributed power resources to participate in market transactions

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Abstract. Customer side distributed power resources are of great significance for low-cost guarantee of supply and demand balance and system peak shaving, and participation in market transactions is conducive to reducing project operation costs. Connotation and types of customer side comprehensive resources are analyzed, constructing the driving factor index system for customer side resources to participate in market transactions, including three indicators: internal rate of return of project investment, cost performance of participating in transactions and meeting their own electricity demand, and the perfection of supporting policies for participating in transactions, and evaluating the key driving factors for current relatively mature gas-fired CCHP, distributed photovoltaic power generation, electrochemical energy storage and demand side response resources to participate in market trading, putting forward the implementation path suggestions, promoting the large-scale and normalized trading of qualified customer side resources.

1. Introduction
After the distributed generation, energy storage, adjustable load and other customer side resources are added to the power grid tie line, information communication, production control system, the customer side comprehensive resources are formed, which directly supply power to users or reduce user load. Compared with the traditional centralized power generation with large-scale and giant characteristics, customer side resources have the characteristics of relatively high security, low investment and strong environmental protection [1]. Therefore, in some technical performance and application scenarios, customer side resources have incomparable advantages over centralized power generation, and customer side resources can form a good complementary relationship with centralized power generation.

At present, the research on customer side resources tends to focus on the micro project operation level of single technology R & D and bidding decision [2-4]. There is no systematic research on the main driving factors, urgency and implementation path of different types of customer side resources participating in the transaction.

This paper analyzes the connotation and types of customer side resources, studies the driving factor index system of customer side resources participating in market transactions, and evaluates the key driving factors of different types of customer side resources.
2. Connotation and types of customer side comprehensive resources

Customer side comprehensive resources refer to the physical form formed by distributed power generation, energy storage, adjustable load and corresponding power grid tie line, information communication, production control system, which have the ability to interact with the power grid on the power consumption side.

According to the technical types of customer side resources, they can be divided into three categories: distributed generation, energy storage facilities and adjustable load, as shown in Figure 1.

(1) Gas fired CCHP

Combined cooling, heating and power (CCHP) refers to the operation of gas-fired power generation equipment such as gas turbine or internal combustion engine generator driven by natural gas as the main fuel. The generated power meets the power demand of users. The waste heat discharged from the system is used to supply heat and cooling to users through residual heat recovery equipment (waste heat boiler or waste heat direct fired machine).

(2) Distributed photovoltaic power generation

There are two main structures of distributed generation system with photovoltaic power generation: one is DC bus distributed photovoltaic power generation system, which is characterized by parallel connection of power generation units, energy storage equipment and power load on the common DC bus; The other structure is the AC bus distributed photovoltaic power generation system, which is characterized by the parallel connection of each generation unit and power load with the main network.

(3) Electrochemical energy storage

At present, electrochemical energy storage technology (lead-acid battery, lithium-ion battery, high temperature sodium battery, liquid flow battery, etc.) is the key field of energy storage industry research and development in various countries. Electrochemical energy storage is mainly used in centralized renewable energy grid, auxiliary services, user side, grid side and other fields.

(4) Demand side response resources

Demand side resource is a kind of load resource to meet the demand of power system resource sufficiency and meet the safe and stable operation of power system by increasing or decreasing power demand. Correspondingly, demand side response resources refer to flexible load resources that can reduce the load level and delay the investment of new installed capacity on the power side through a series of technical means and management rules. They are divided into load resources based on time-sharing price and economic incentive.

3. Driving factor index system for customer side resources to participate in market transactions

After extensive research and analysis, the main driving factors for all kinds of customer side resources to participate in the market transaction are the internal rate of return of project investment under the
leading price system, the cost performance of participating in the transaction and meeting their own electricity demand, and the perfection of supporting policies for participating in the transaction.

3.1. Internal rate of return of project investment

There are differences in investment cost, income mode and income level of different types of customer side resources, which are usually measured by technical and economic evaluation methods [5]. The calculation process is as follows:

(1) System initial investment $K_0$
   It mainly includes equipment investment, control system investment, etc.

(2) Operating cost $C_{fm}$
   After the system is completed and put into operation, the system cost is generally composed of operation cost, maintenance cost and fuel cost (such as CCHP distributed generation). When the project is completed, the operation cost and maintenance cost are relatively fixed, and the change factors are less, which can be called fixed cost.

(3) System revenue analysis
   For the customer side integrated resource system, there are two main economic benefits ($R_{al}$) after the system is built and put into operation: power supply revenue ($R_e$), cold and hot revenue $R_c$ and $R_h$ (if any).
   \[ R_{al} = R_e + R_c + R_h \]  

(4) Financial index of project economic evaluation
   Economic effect evaluation is the core content of investment project evaluation. There are many kinds of economic effect evaluation indexes, which reflect different economic angles of the project. Three main indexes, namely payback period, net present value and internal rate of return, are often selected for economic analysis of investment projects.

   Static payback period $T_J$: payback period without considering time value.
   \[ T_J = \frac{K_0}{A_t} \]  
   Among them, $K_0$ is the initial investment; $A_t$ is the annual net income.

   Dynamic investment payback period $T_D$: investment payback period considering time value.
   \[ T_D = -\frac{\lg(1-K_{i0}/A_t)}{\lg(1+i_0)} \]  
   Among them, $i_0$ is the benchmark discount rate.

   NPV refers to the difference between the total present value of the investment project income and the initial investment.
   \[ NPV = \sum_{t=1}^{n} \frac{F_t}{(1+i_0)^t} - K_0 \]  
   Among them, $F_t$ is the cash flow of the project in year $t$.

   Internal rate of return (IRR) is the rate of return on investment of the project itself, which refers to the discount rate when the present value of net cash flow of each year is equal to zero in the whole calculation period. The internal rate of return (IRR) reflects the resilience of the project to investment expenditure; The higher the value, the better the economy of the scheme. When the internal rate of return is greater than the benchmark rate of return, the project is acceptable. It is an important financial index to evaluate investment projects.
   \[ \sum_{t=0}^{n} A_t(1+IRR)^{-t} = 0 \]  

   In general, the higher the IRR and the shorter the payback period, the better the project.
3.2. Cost performance of participating in trade and meeting own electricity demand
An important role of customer side resources is self use (demand response can also be used as a kind of virtual generator). Whether all kinds of customer side resources have strong power to participate in the transaction depends on their own electricity consumption cost and transaction cost. If the economy of priority self use is higher than that of participation in the transaction, customer side resources also have no strong power.

The cost performance of participating in the transaction and meeting their own electricity demand = the income from participating in the market transaction / (power supply cost of large power grid - power supply cost of self use) (7)

The difference between the power supply cost of large power grid and the power supply cost of self use is positive, and the larger the ratio is, the stronger the motivation of such customer side resources to participate in the transaction is.

3.3. Perfection of supporting policies for participating in transactions
The degree of policy perfection includes market mechanism supporting conditions such as access, trading varieties, deviation assessment, settlement and auxiliary services, which directly affects the participation of customer side resources, trading scale and income level. The index is studied and judged by qualitative analysis.

4. Evaluation of key drivers of different types of customer side resources
This paper makes a comparative analysis of the relatively mature gas-fired CCHP, distributed photovoltaic power generation, electrochemical energy storage and demand side response resources. Based on the comparative analysis, the internal rate of return of the project investment, the cost performance of participating in the transaction and meeting their own electricity demand, and the perfection of supporting policies for participating in the transaction are scored respectively. ★, ★★, ★★★ respectively represent low, medium and high. The evaluation results are shown in Table 1.

Table 1 Evaluation results of key drivers of different types of customer side resources

|                              | Internal rate of return of project investment | Cost performance of participating in trade and meeting own electricity demand | Perfection of supporting policies for participating in transactions |
|------------------------------|-----------------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------|
| gas-fired CCHP              | ★★★                                          | ★★                                                                        | ★★                                                              |
| distributed photovoltaic power generation | ★★                                           | ★★★                                                                      | ★★                                                              |
| electrochemical energy storage | ★                                            | ★★★                                                                      | ★★★                                                            |
| demand side response resources | ★                                            | ★★★                                                                      | ★★★                                                            |

A more intuitive radar chart is adopted, as shown in Figure 2. The following conclusions can be found:

For gas-fired CCHP, the driving force to participate in the transaction is relatively weak, and low-cost electricity and heat / cold consumption are the main requirements.

Distributed photovoltaic power generation, electrochemical energy storage, demand side response resources to participate in the transaction have strong demands to reduce user operating costs and improve additional income. Distributed photovoltaic power generation has a higher level of investment income. Therefore, the transaction supporting policies should be improved as soon as possible to promote its large-scale and normalized transaction.

At the present stage, the government departments in charge should ease the problem of low rate of return through investment subsidies, relevant costs into the transmission and distribution price and other strategies, so as to expand the scale of investment and participate in market transactions as soon as possible.
Figure 2 Differences of driving factors for different types of client side resources to participate in transactions

5. Conclusion
There are many types of customer side resources. Taking scientific evaluation model, comprehensively considering the technical and economic feasibility, the urgency of participating in the transaction and the perfection of the policy system, is helpful to reasonably plan the implementation path of customer side comprehensive resources participating in the transaction. In this way, it can not only adapt to the objective laws of the transaction system and the perfection of the transaction system, but also promote the large-scale and normalized transaction of qualified customer side resources.

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