Multi-Objective Optimized Operation Model Based on Demand Side Grid

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Abstract. The multi-objective optimized scheduling model is proposed considering demand side management. The load side resources are divided into nine categories based on three characteristics of fixed, transferable, and user-action loads. The management of transferable load is especially significant based on the example calculation in many regions. In the case of time-of-use price, the multi-objective optimization scheduling method with the objectives of minimizing the total operation cost of demand side energy grid is established. The economic utilization scale is calculated based on the collaborative utilization mode of user side resources and power supply. The numerical tests for the micro-grid indicate that with demand side management consideration, the total cost reduces significantly.

1. Resource potential analysis in user-side

User-side resource type. The user-side resources are equipment devices which are installed on the power consumption side, belong to the user. There are nine types of user-side resources: Power generation equipment includes self-supplied power plant, combined cooling, heating and power, etc. Electrical equipment includes industrial production, air conditioners, smart homes, electric vehicles, etc. Energy storage devices include user-side energy storage, electric heat storage, ice storage, etc.

| User-side resource                  | Non-user side resources                  |
|------------------------------------|------------------------------------------|
| Industrial production              |                                |
| Air conditioning load              | User side energy storage                |
| Electric car                       | Flexible power supply                  |
| Smart home                         | Combined cooling, heating and power     |
| Captive power plant                | Ice storage                              |
| Electric heat storage              | Grid Optimal Dispatch                   |

Assessment method. The proportion of user-side resources involved in peak cutting, valley filling, and accurate real-time load control is determined using the method that combines theoretical analysis and engineering experience considering physical operating characteristics, user habits, and willingness to interact, and adopt a method that combines theoretical analysis and engineering experience. User-side resources participate in normal operation and regulation under the constraint of the maximum available proportion.
Various user-side resources can participate in peak cutting, valley filling, and accurate real-time load control is determined according to equipment characteristics and usage habits. The comprehensive utilization value of user-side energy storage, industrial production, and smart home is high which can participate in peak cutting, valley filling, and accurate real-time load control at the same time. User-side resources can also participate in normal operation adjustment.

![Diagram: Assessment method]

**Figure 1. Assessment method**

The proportion of user-side resources available is evaluated using theoretical analysis and engineering experience methods. The proportion of user-side resources available is determined combining the physical characteristics, operating constraints and user habits and wishes of typical equipment. Using the engineering experience method to determine the proportion of user-side resources available refer to the actual utilization ratio of user-side resources in other regions in the country.

**Table 2. Utilizable ratio of various types of user-side resources**

|                          | Peak clipping | Valley filling | Accurate hour load controlling |
|--------------------------|---------------|---------------|-------------------------------|
| Air conditioning load    | 12            | —             | 13                            |
| electric car             | 16            | 19            | —                             |
| User side energy storage | 87            | 88            | 2                             |
| Industrial production    | 24            | 9             | 26                            |
| Captive power plant      | —             | 11            | —                             |
| Cooling, heating and power triple | —          | 18            | —                             |
| Electric heat storage    | —             | 80            | 13                            |
| Ice storage              | —             | 10            | 16                            |
| Smart home               | 24            | 29            | 22                            |

The proportion of energy storage available on the user side is the highest that the proportion of participating in peak shaving and valley filling is as high as 90%, and the proportion of participating in accurate real-time load control is as high as 30%. The proportion of industrial production participating in valley filling is 10%, and the proportion of participating in peak shaving and precise real-time load control is as high as 25%.
2. User-side resource utilization method

In terms of planning and design. The overall planning system of power supply planning, power grid planning, and user-side resource planning has been established bring user-side resources into the scope of power planning work.

In terms of scheduling operations. The value of new energy consumption of user-side resources, balance of power supply and demand, and power grid accident support has been brought into play.

In terms of marketing services, user-side resources are aggregated into the power marketing service network, which establish a large-scale, full-category user-side resource library covering cold, heat, electricity, and gas. The platform value of the company's integrated energy services has been brought into play.

3. Business system

The business system for user-side resource utilization is established. That is designed of eight major businesses in planning and design, scheduling operation, marketing services, etc.

| Planning and Design | (1) Power planning business based on user-side resources |
|---------------------|--------------------------------------------------------|
| Scheduled           | (2) Accurate real-time load control business            |
|                     | (3) Source Net load friendly interactive service        |
|                     | (4) Virtual Power Plant business                        |
| Marketing service   | (5) Demand response business                           |
|                     | (6) Load integrator                                    |
|                     | (7) User-side energy storage business                   |
|                     | (8) Electric vehicle and grid interactive business      |

Power planning business based on user-side resources. Power planning based on user-side resources, Power grid planning based on user-side resources.

Precise real-time load control. Building accurate real-time load control system. Researching mass, decentralized load control technology.

Friendly interaction between source and network. Construction of interactive management platform for source network load, application of system reserve capacity optimization method considering user-side resources, service electricity direct transaction and ancillary service transaction, market information release and market transactions for electric power users.

Virtual power plant. Construct a virtual power plant diversified cooperation network. Perfect the key business of the virtual power plant. Establish online and offline service channels. Establish a virtual power plant to participate in the market transaction benefit distribution mechanism.

Demand response. Establish a complete demand response work system. Improve the demand response implementation framework. Guide users to optimize power load and actively participate in demand response.

Load integrator. Cultivate load integrators in the system. Establish a comprehensive load integrator with large user-side resource entities outside the system. The external load integrator of the service system participates in the user-side resource utilization business.

User side energy storage. Build a nationwide energy storage cloud platform to serve the dispatch and operation of the power grid. Strengthen technical support for user-side energy storage. Actively explore diversified new business models.

Electric vehicles interact with the grid. Deploy interactive applications for the car network. Deepen industrial cooperation and build a standardized technical framework for vehicle-network interaction. Develop smart terminals with charge and discharge control functions. Develop a charge and discharge control strategy that meets the grid load and user needs.
4.  business model
The essence of the business model is the transaction structure formed by internal and external stakeholders. The six-element business model model can support the construction of user-side resource utilization business models.

Demand response business model. The fund pool is formed through peak electricity prices or special funds. Users respond to the market based on incentives or price signals which receive response subsidies in accordance with prescribed standards.

Load integrator business model. Load integrator performs demand response and accurate real-time load control response which Incentive compensation through electricity market transactions or load control.

Virtual power plant business model. Participating in the auxiliary service market, real-time market, and energy efficiency management by aggregating users. VPP operators share revenue with users.

User-side energy storage business model. User-side energy storage operators participate in demand response accurate real-time load control response, which incentive compensation through power market transactions or load control.

Electric vehicles interact with the grid. Charging facility operators perform orderly charging and discharging on behalf of electric vehicle users which participate in demand response, accurate real-time load control response and Incentive compensation through electricity market transactions or load control.

5. Conclusion
Research ideas are studied including trend research and judgment, problem identification, propose system solutions, and realize coordinated development. The development model and the direction of business innovation are analyzed in the paper. The development trend of system form, network element, operation mode, service format, etc. has been clarified. The user-side resource utilization potential is studied, the user-side resource utilization status and utilization potential are analyzed, and the idea of strengthening the user-side resource utilization is proposed.
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