Demand Response Business Process Design Considering Ubiquitous Functionality

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Abstract: The reformation of the electric power market and the application of new technology of source network load storage provide the basic conditions for the user side resources to participate in the grid interaction. More and more flexible resources, such as air conditioner, water heater and other smart home appliances, as well as new resources such as electric vehicles, distributed power supplies and energy storage, can participate in the demand response market. It is necessary to systematically analyse and design the whole process of demand response business. This paper aims at the demand response business, this paper sorts out the correlation among the participants, and designs the static relations and dynamic relations business processes of demand response based on the functional tree decomposition model. Taking the business flow as the main line, the paper designs the four-link demand response business implementation system architecture that contains energy flow, information flow and business flow.

1. Introduction
DR (Demand response) can promote the grid peak load shifting and renewable energy consumption and improve the energy utilization efficiency. In China, DR platform is built based on relevant business application systems of grid enterprises (such as load management control system and electricity information acquisition system, etc.), and the power user side load resources are regulated uniformly by recruiting load aggregators[1-3]. Meanwhile, China's DR mechanism and project design, in most cases, are led by the government. Participating users are mainly industrial and commercial users, and the pilot scope is small. With the deepening of marketization reform and the development and application of new technologies, interruptible load contracts which signed by administrative requirements planning and encouraging users with the electric power companies will reduce gradually, while automated demand response will become one of the core technology function of safe and efficient development of the grid[4-5]. Demand response should be brought into the real-time scheduling, and real-time adjustable potential of load should be utilized fully to improve the system intermittent energy access ability and the safe and stable operation ability[6-7].

2. Design Approach
Business activity refers to the process in which an individual/organization USES a series of activities to accomplish a certain goal within a certain period of time, accompanied by the transmission and communication of information. Scene design is an abstract representation of the process of real activities with the help of entity or virtual forms of expression. Business scenario design is an abstract modelling process of business realization through text, graphics, charts and other forms of expression.
Firstly, key elements are extracted, static diagrams are established according to the relationships of each element, and then dynamic sequence diagrams are used to describe the interaction process of each element. Finally, a three-flow fusion diagram is constructed.

3. Static Relations of Demand Response

In the business scenario of power users participating in demand response, the specific business roles involved mainly include electric power suppliers, load integrators, power users and the government regulatory department.

Electric power suppliers mainly refer to electric power companies. They conclude demand response plans by monitoring the power system in real time. Through the DR management system (a platform), they carry out the formulation and release of the response plan, the management of the DR contracts, the evaluation and settlement on the DR execution effectiveness and other core businesses. Electric power companies can directly connect with load integrators or power users with a large amount of resources in response.

DR regulators are mainly governmental authorities, independent of electric power companies, load integrators and power users. Due to the interests of the parties involved the demand response, so in order to ensure the electric power companies, load integrators and power users are able to carry out automated demand response projects fairly and impartially, safeguard the vital interests of each participant in electricity market and the benign development of the electricity market, the activities of the main bodies in the market are comprehensively regulated by DR regulation system.

The load integrators are responsible for aggregating the scattered responding resources that do not meet the minimum participation constraints and packaging and managing them to participate in the automated demand response business. From the perspective of system operation, the integrated utilization of responding resources can delay or avoid the investment in building new power networks due to the increase of load and improve the operation efficiency of electric power system. From the perspective of load, load integrators provide an opportunity for small and medium loads to participate in the automated demand response business and market transactions. By means of professional technical measures, the response potential of load is fully tapped, idle responding resources can be developed, and power users cultivate a scientific way to use electricity, enhance the power consumption efficiency of terminal electrical equipment, and also bring benefits to other power system participants.

Power users are the suppliers of responding resources, and they belong to the responders. Whether it is load reduction or power supply to the internet, users can achieve power balance of the electric power system by changing their own power supply and consumption behaviours, to play the role of peak load shifting and auxiliary reserve. At the same time, in the process of participating in the automated demand response, users can obtain certain economic benefits and foster a good awareness of energy conservation and environmental protection.

According to the demand response direct load control (DLC- direct load control), the case analysis is conducted, a static relations figure is shown in figure 1.
4. Dynamic Relations of Demand Response

According to the static diagram, similar classes and relations are summarized and combined, and the dynamic model-sequence diagram is further constructed by abstracting the model, as shown in figure 2. Among them, when the power grid needs to carry out DLC dispatching plans, the power grid side will firstly send instructions to the power operators, who will sign the contract with the users through the relevant information of DR market management. Then, demand response management system creates the DR projects, select the corresponding users and return the corresponding information. After the DR projects are created and responded, the dispatching system issues dispatching instructions to the DR management system, and finally to the user energy management system for load control and returning the corresponding. After the load response and control are completed, the power operators issue the query instructions to the power consumption information management system to obtain the load power consumption information and make the settlement. Finally, power operators will feedback the entire measurement and settlement information to the grid companies, including the DLC execution results.

![Figure 1. Static Diagram on Demand Response DLC Business](image-url)
5. System Architecture of Demand Response
Demand response business process is decomposed and refined into 4 segments, including the early stages of response, response scheme decision, response implementation, response effectiveness evaluation and cost settlement. Guided by automated demand response operation mechanism, taking business flow as the main line, 4-segment demand response business implementation process chart, including energy flow, business flow and information flow, is designed to realize the two-way interaction of energy flow, business flow and information flow between power users and the power grid. The specific business activities involved in 4 segments are as follows.

5.1 Early Stages of Response
Basic Information Research. Before the business development, the electric power companies firstly need to research and establish the user threshold value to participate in the automated demand response, that is, the user application conditions (such as regulations on the user response capacity, response times and response time period, as well as requirements on the load control management facilities). Load integrators will participate equally by aggregating multiple power users as individual users.

Signing Response Contracts. Based on the confirmation of basic information, the electric power companies, load integrators and power users shall participate in the negotiation and sign the response contracts.
5.2 Response Scheme Decision
Response Scheme Decision. When grid load peak (peak-valley difference) reaches a certain limit or insufficient grid spare capacity causes the overload of local load or other uncertain factors cause power grid emergencies, electric power companies need to make decisions and develop demand response plans based on the actual load operation of power grid. According to the actually demanded load reduction amount, the electric power companies needs to determine the invitation scope, and informs the power users (load integrators) of the demand response quantity, response time and electricity price compensation policy, with the help of modern information means (Internet mobile, mobile APP and WeChat).

Response Ability Confirmation. When power users and load integrators receive the response invitation, they need to timely feedback whether to participate in the response plan. The response centers will calculate whether it can meet the response capacity by the feedback information. If not, then they will continue to expand the scope of invitation until it is satisfied. And they will feed the final information back to the electric power companies and government regulatory departments (the Economy and Information Technology Department or the Price Bureau).

5.3 Response Business
Implementation of Response Plans. The electric power load management system will issue the execution instructions to the response terminals of the power users and the load integrators, and execute the response operation according to the agreement. The decision execution right of the power users, who are aggregated and represented by load integrators, is completed by the load integrators.

Execution Result Record. The electric power load management system and the power demand side management online monitoring platform shall record and verify the response result information (mainly including the response quantity and response time, etc. of users participating in the plan).

5.4 Response Effectiveness Evaluation and Cost Settlement Business
Response Effectiveness Evaluation. After the execution of the response events, according to the response quantity and response time of the user load (equipment) collected by the electric power load management system and the electric power demand side management online monitoring platform, the effectiveness of the response shall be evaluated by the evaluation standard and calculation method agreed in the contract. Then the evaluation result of the response effectiveness shall be obtained.

Cost Settlement. According to the user's response quantity, response times, response time, actual electricity price and incentive compensation measures, the cost settlement is completed by the calculation methods agreed in the contract. The business structure of demand response as shown in figure 3.
Figure 3. Automatic Demand Response Business Process Design

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