Research on Business Model of Virtual Power Plant for New Power System

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Abstract. Virtual power plant is a collection of multiple distributed power sources, loads and energy storage devices. It can operate as a special power plant and provide demand response services and grid auxiliary services. Customer portrait technology can be used to accurately locate high-quality users with high willingness to participate and high demand response potential. At the same time, personalized services can be formulated according to the portrait results, so as to improve the participation enthusiasm of end users and provide reference for the study of commercial development financing mode of virtual power plants.

Keywords: new power system; virtual power plant; business model; canvas research

1. INTRODUCTION

Virtual power plant aggregates different types of distributed energy such as distributed power generation, energy storage system and demand response resources through advanced control, metering, communication and other technologies, and uses a higher level software architecture to coordinate and optimize the control of load resources and distributed power generation, so as to realize the rational optimal allocation and utilization of resources. Virtual power plant can not only supply power to the grid, but also absorb surplus power of the grid. It has a dual identity of "source load" and can provide auxiliary services such as frequency modulation and peak shaving to the grid through friendly interaction between source and load. Virtual power plant provides an effective way to solve the problem of new energy consumption and low-carbon energy transformation.

The literature [1-2] is a combination of wind power and electric vehicles to form a Virtual power plant. Through the joint optimization of wind power and electric vehicles,

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the advantages of wind power companies and electric vehicle companies are complementary, so as to play a stronger market effect and enhance profitability. The literature [3] proposes to jointly optimize the operation of electric vehicles and schedulable loads, still achieving better market competitiveness through mutual complementarity. In order to optimize energy allocation and energy efficiency, literature [4] uses the Virtual power plant mode to aggregate distributed energy such as heat and power online units to participate in market transactions as a whole, and considers that the adjustable operation mode of unit heat and power ratio breaks through the traditional limit of determining power by heat and improves the flexibility of unit scheduling. Literature [5] further expanded the membership of Virtual power plant to multiple energy sources such as wind, light and water, whose fundamental purpose is still to improve the external performance of Virtual power plant.

Big data technology can comprehensively cover the two-way interaction data between users and the power grid, with more diverse data types and larger data scales, laying the foundation for multi-faceted user behavior analysis and endowing traditional power system analysis with new connotations. The virtual power plant completes the aggregation of distributed resources, the power dispatch center issues automatic generation control instructions, the data acquisition and monitoring control system performs optimization calculations and instruction decomposition, and finally sends the instructions to the user's intelligent terminal to complete the control of user resource equipment. Not only can users on the load side adjust their own electricity consumption increase or decrease, but they can also convene energy storage measurement and power side users to adjust electricity output, simultaneously meeting the needs of peak shaving and valley filling.

The business model portrait technology of Virtual power plant is a labeling process abstracted from the user's social attributes, lifestyle, energy consumption behavior and other information. Tagging is a highly refined feature identification method that visualizes data and is the foundation of power customer profiling technology. Establish a multi feature label classification recognition model to achieve feature to label mapping and form an overall picture of power customers.

2. CUSTOMER CULTIVATION IN BUSINESS MODELS

The customer part of the virtual power plant mainly analyzes customer segmentation, customer relationship and distribution channels from the perspective of customers. Virtual power plants are mainly divided into the following types. One is the load-side virtual power plant. This type of operator is not affiliated to the traditional customer's power supplier, but also can be used as a power supplier to become a balanced responsible party. The second is the integration of source-grid-load-storage. Large power companies aggregate their own power generation resources and possible load users and generator sets into virtual power plants. As power companies, they are balanced responsible parties. Third, independent and flexible joint virtual power plants, new market participants, especially manufacturers of

small-scale distributed energy resources, mainly aggregate their users ' resources into virtual power plants.

Table 1 Three modes of virtual power plant

	Load-side virtual power plant	The integration of source-grid-load-storage	Independent and flexible joint Virtual power plant
Device Type	Residential and industrial loads	New energy, load, energy storage	New energy, load, energy storage, gas, cold, heat and other resources
Construction architecture	Electricity price incentives	Fixed union	Dynamic Resource Pool Management
Market applications	Intelligent building group control, deep peak shaving, valley filling	Energy aggregator, shared power supply	Participate in market transactions
Interaction	User Response	User response, intelligent regulation, and electricity trading	User response, resource sharing, intelligent regulation, electricity trading, cooperative competition, market gaming

2.1 customer segmentation

Customer segmentation is mainly the different target groups and institutions that the virtual power plant institutions want to obtain and expect services. Because the virtual power plant is in the middle position of the value chain of power transmission and utilization, the virtual power plant involves many customers, mainly composed of transmission network operators, distribution network operators, distributed power supply operators, power sales companies, large users and small users. Virtual power plant operators can assume one of the functions of the above customer types, as shown in Table 2.

Table 2 Virtual power plant in different customer function analysis

customer	function
electricity retailer	It is responsible for coordinating information with different electricity selling companies, determining the share price of each electricity selling company and making a quote to the power grid.

Power grid managers	Interactive information such as power generation plan with grid managers, formulate rules for grid managers to participate in the market, and be responsible for market supervision.
Distributed Power Operators	The virtual power plant can be used as a backup resource to provide backup services for distributed power supply operators, and alleviate the intermittent power generation through complementary operation.
Retail users	Sign a retail agreement with the virtual power plant, purchase electricity from the virtual power plant according to a fixed or variable electricity price, and provide demand response to the virtual power plant.

2.2 Customer Relationship

The customer relationship mainly describes the type of customer relationship established by the virtual power plant for the customer group. The service concept of the virtual power plant should be customer-centric, and build strategies that adapt to customer relationships and maintain strong and long-term relationships for different target customer segmentation structures. Customers are divided into strategic customers, partner users, important users and general users. Aiming at the needs of strategic customers and partner users such as distribution system operators and distributed power operators, the solutions suitable for the customers are studied, and the services are continuously improved and improved, and finally a symbiotic cooperation relationship is formed. For important customers such as massive small users and general customers, it is necessary to maintain customer stickiness and fully tap the potential of user needs, and maintain the social influence brought by massive users through good customer relationships. The virtual power plant customer classification is shown in Figure 1.

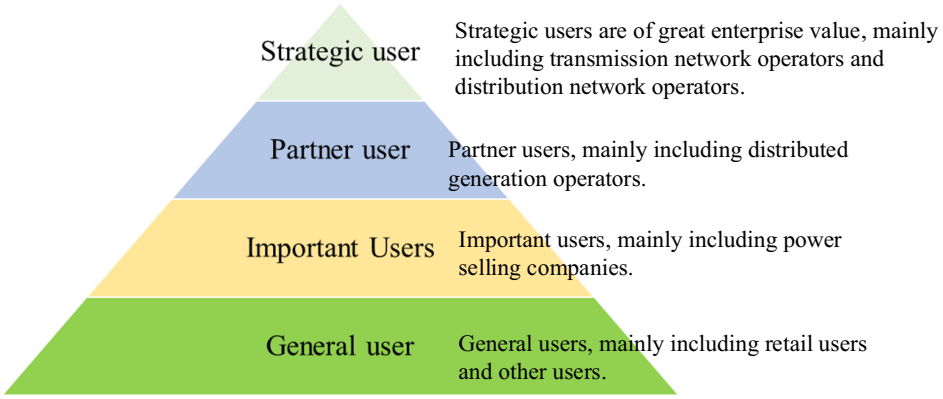

Figure 1 Virtual power plant customer relationship classification

2.3 Channel access

Channel access is mainly to describe the virtual power plant to communicate with the customer group and establish contact, in order to pass their own value proposition to the other party. For different virtual power plant operators, they often use different ways to open up channel channels according to their own core resources, establish relationships with customers and convey value propositions. Virtual power plant can carry out virtual power plant related operation related business through its core technical advantages in power grid operation and trust with customers. Emerging technology virtual power plants such as the Internet can make full use of their advantages in platform technology to carry out energy services based on the Internet platform.

Virtual power plant realizes the functions of data acquisition, monitoring, control and optimization of distributed resources through collaborative management and control platform or digital management and control platform. According to the market price signal or the system operation state, the optimal scheduling or incentive mechanism design of distributed resources can be carried out to maximize the benefit or minimize the cost.

3. BUSINESS MODEL INFRASTRUCTURE CONSTRUCTION

3.1 core business

The construction party of the virtual power plant system needs to rely on digital technologies such as the Internet of Things, cloud, and big data to achieve organic organization, aggregation management, optimization and regulation of various resources at the data level, and thus realize the main value of the virtual power plant. The core business of virtual power

plant is to ensure the normal operation of its business model. For virtual power plant operators, their core business can be divided into the following aspects, as shown in Figure 2.

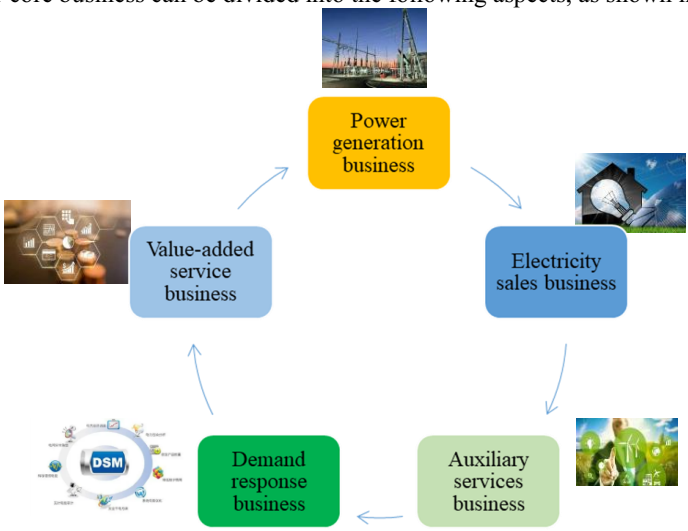

Figure 2 Virtual power plant core business

Power generation business. The business is mainly through the virtual power plant in the massive wind power, photovoltaic power generation and other distributed power aggregation, and then participate in the electricity market bidding, so that the distributed power to participate in the electricity market competition.

Electricity sales business. The business mainly meets the electricity demand of users inside the virtual power plant by using the power produced by the distributed power supply inside the virtual power plant and the external power market.

Auxiliary services business. This business is mainly through the virtual power plant in the massive controllable distributed power and energy storage system and other flexible equipment for effective control, for the transmission system operators or distribution system operators to provide frequency modulation, voltage regulation, reserve capacity, black start and other auxiliary services, so that the distributed power to participate in the power service market.

Demand response business. This business is mainly involved in demand side response and demand side management by aggregating user load requirements within the virtual power plant, especially flexible loads such as electric vehicles.

Value-added service business based on big data. Through the use of modern Internet information technology, pattern recognition, feature extraction and behavior analysis of customer's electricity information are carried out to provide users with value-added services such as energy consumption analysis, energy saving suggestions and electricity price comparison.

3.2 core competence

In terms of core resource capabilities, it mainly refers to the most important resources and technologies needed by virtual power plants to ensure the smooth operation of business models. Internet technology virtual power plant has unique advantages in Internet platform, big data, cloud computing and artificial intelligence technology, user stickiness and so on.

Different business entities have different core resource capabilities for carrying out virtual power plants. The traditional power grid virtual power plants are mostly heavy asset virtual power plants. The virtual power plants are large in scale and have superior resources such as qualifications, technology, capital, customer and offline service capabilities. Emerging energy virtual power plants (such as Xiexin, Xin 'ao, etc.) have strong distributed energy and other industry-related technical capabilities, equipment capabilities and network platforms.

The implementation of observable, measurable, and controllable functions of virtual power plants is centered on the level of digital technology. Virtual power plants aggregate diverse power resources at the physical level, and to achieve organic aggregation of these resources and flexible scheduling on this basis, high requirements are placed on the digital level of the construction and operation of virtual power plants.

3.3 Important partners

Important partners, mainly refers to the virtual power plant in order to ensure the smooth operation of the business model required by the supplier and partner network. Important partners help virtual power plants reduce the risks and uncertainties of virtual power plant applications, obtain the resources and capabilities required for virtual power plant applications, and design and optimize the business model of virtual power plants. For example, ICT providers have the knowledge, experience and skills necessary to face and address these ICT challenges. In addition, all major suppliers, distribution channels and customers in the supply chain are important partners necessary for the virtual power plant to realize the commercial value of the virtual power plant.

The construction and operation of virtual power plants also pose high digital technology requirements for network communication and management, information security, hardware infrastructure construction, and other aspects within the plant. In terms of network communication and management, based on technologies such as virtual private networks and wireless communication, we establish communication links between the control center and internal and external objects from both physical and data levels, and develop dedicated communication protocols and platforms.

4. VALUE PROPOSITION

Based on user characteristics, an electricity external characteristic model is established to guide users to actively participate in the demand response of the power system, providing refined data on user electricity behavior for power grid companies. Virtual power plants are essentially an automation software platform system that aggregates distributed power sources, distributed energy storage, and demand side flexible loads. The value proposition is the value created by the application of Virtual power plant for itself, business partners and even the society to solve or meet some problems and needs of its target customers. The value proposition of Virtual power plant mainly includes three aspects: economy, safety and environmental protection, as shown in Table 3.

Table 3 the value proposition of virtual power plant

value aspect	value embodiment
In terms of economic value	Through advanced ICT technology to aggregate and optimize distributed energy equipment, improve the efficiency of energy market operation, tap new energy value for customers, improve customer economic benefits, and reduce user energy costs.
In terms of safety value	Excavate the support of distributed energy equipment for the safe operation of power system, such as frequency modulation and voltage regulation services of distributed energy equipment, to ensure the safe and stable operation of power system under the condition of increasing access ratio of distributed energy equipment in the future.
In terms of environmental value	By improving the grid-connected friendliness of distributed renewable energy, the proportion of renewable energy access in the system can be further increased, thereby reducing greenhouse gas emissions.

The profit model of Virtual power plant is a profit collection channel formed through the introduction of differentiated business. When implementing service businesses such as clean energy supply, network platform operation, smart energy services and big data value-added services, there are three profit collection channels: energy product fees, energy service fees and value-added service fees. The profit model of Virtual power plant is shown in Figure 3.

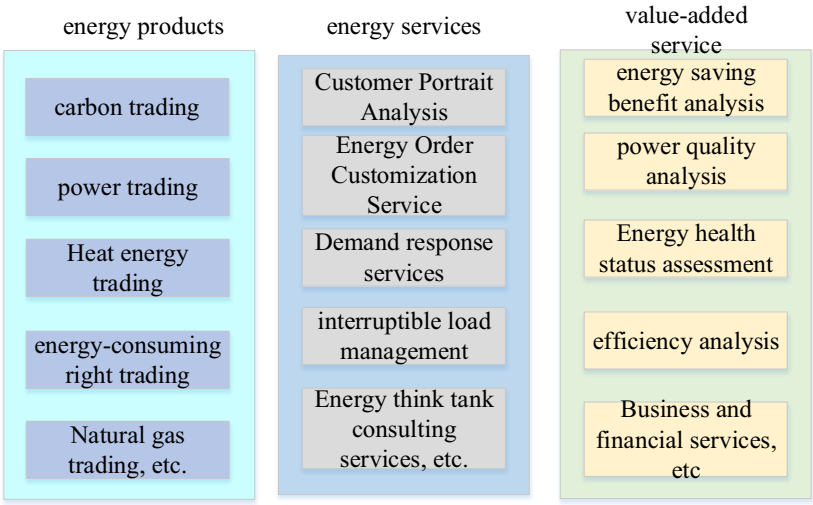

Figure 3 Virtual power plant profit model

5. CONCLUSION

By utilizing big data technology and load clustering theory to extract the electricity consumption and social characteristics of diverse users, a user profile containing electricity consumption and social characteristics is constructed. Building a business model to promote and encourage various types of resources to participate in the operation and management, which will help Virtual power plant to play its scale effect. The specific suggestions are as follows.

First, at the initial stage of construction and pilot of Virtual power plant, combined with the development status of China's power market, it is suggested to fully learn from the construction and operation experience of various typical Virtual power plant such as power generation aggregation and load aggregation abroad in terms of investment management mode, interaction and optimization with market operation agencies, etc.

Second, China should introduce and improve supporting policies for virtual power plant and relevant market rules as soon as possible. It is suggested that the government and relevant departments should closely combine the needs of Virtual power plant construction and power market promotion, and issue policies and rules including Virtual power plant investment management, market access, market participation rules, and operation subsidies.

Third, establish a price mechanism for Virtual power plant to participate in the electricity market. Establishing and clarifying the price mechanism of Virtual power plant in advance will help clarify the competitiveness of Virtual power plant in the market and promote the investment and construction of Virtual power plant by all parties.

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