A Decision Support System of Premium Power Supply Investment

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***Abstract*—With the increasing demand of sensitive users for premium power supply, power grid companies rely on traditional information management and service methods which are far from meeting the requirements of the power market in the future. Therefore, it is very urgent to use the decision support system of premium power supply investment with the ability of flexible query, online analysis and processing, and auxiliary decision-making. The design ideas and methods of the system are illustrated from three aspects: the architecture, the function modules and the application of the system. The system consists of three parts: user information input, user demand quantitative processing and decision-making output. Users and power grid companies can access information data at will, make correct and timely decisions quickly, and display the results with intuitive and clear charts to improve the practicability of the system. Finally, the feasibility and effectiveness of the decision support system of premium power supply investment which has been successfully applied in a certain area of South China are illustrated.**

Keywords—premium power supply, decision support system, user demand, voltage sag

I. INTRODUCTION

With the development of society and technology, more and more automation technology, power electronic equipment and computers are applied in industrial production. These equipment are very sensitive to voltage sags[1]. The economic loss caused by voltage sags in the production process of industrial users is huge and the influence caused by voltage sag is prominent[2-4]. They are eager to get premium power supply to reduce the loss and improve production reliability. However, at present, the industrial users lack of considerable knowledge of their own power supply demand, and it is difficult to choose a premium power supply investment scheme suitable for them. Under the background of power market reform, power grid companies begin to change from the planning centered on power grid itself to the rational planning centered on user demand and considering the enterprise's own benefits in order to improve the reliability of power supply, which is the necessary condition to ensure the competitiveness of power grid companies when the power market is fully mature in the future. The determination of the investment plan of different users' premium power needs to consider the demand of users' premium power supply. On this basis, making a more rational decision on the investment of premium power supply is undoubtedly an effective means to guarantee the quality of users' power supply, reduce the economic loss of users, win more market share for power grid companies and guarantee the core competitiveness.

In recent years, the research on premium power supply investment at home and abroad mainly includes the cost-benefit analysis of the investment scheme itself[5], the selection and optimization of custom power device[6], and other relatively independent contents. It does not integrate multiple research sets of premium power supply investment, form a standardized process, so lack a set of integrated system to guide the development of premium power supply investment decision. The decision support system of premium power supply investment only needs the input information of the user, which can transform the complex calculation process and theoretical knowledge into visual images and clear data to the user directly, improve the readability and operability of the system software, and make the research on investment decision of high quality power supply more concise and clear. In order to help improve the decision-making level of premium power supply investment and avoid the waste of resources caused by a large number of similar research and development work, this paper proposes a general comprehensive evaluation decision support system, which is of great significance, and proves its feasibility and effectiveness through the application of premium power supply investment decision-making system in southern China.

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II. CONCEPT OF PREMIUM POWER SUPPLY INVESTMENT

The meaning of premium power supply is to provide customers with premium power. Premium power refers to the power whose power quality index is higher than the existing public grid power supply regulations and relevant regulations[7]. Premium power supply can bring more benefits to users and meet their power demand. With the gradual opening of the electricity market, users have more choices and participation in the investment of premium power, and their demand and investment willingness for premium power are gradually increasing. At present, users mainly invest in power quality disturbance control to obtain premium power supply, and the power quality disturbance control scheme needs to be designed by professionals and institutions such as power grid companies according to the demands and wishes of users for selection. In this way, the investment of premium power supply mainly refers to the investment of premium power supply scheme. In the face of a variety of premium power supply schemes, investment decisions need to be made. Therefore, through the development of the decision support system of premium power supply investment, to achieve efficient and convenient premium power supply investment decision-making, is conducive to improving the competitiveness of grid companies and user satisfaction.

III. DECISION SUPPORT SYSTEM OF PREMIUM POWER SUPPLY INVESTMENT

A. Concept of Decision Support System

Michael S. Scott Morton put forward the concept of Decision Support System (DSS)in 1971, which was called management decision system at that time. Its main feature is a computer system which can help decision-makers to use data and models to solve bad structural problems in the way of human-computer interaction[8]. With the development, DSS is the latest form of information system formed by electronic data processing and management information system. Based on management science, operation research, cybernetics and behavior science, it is an intelligent man-machine system supporting decision-making activities for semi-structured decision-making problems by means of computer technology, simulation technology and information technology. The system can provide decision makers with the data, information and background materials needed for decision making, help clarify decision goals and identify problems, establish or modify decision models, provide various alternatives, and evaluate and optimize various plans Through analysis, comparison and judgment through human-computer interaction functions, it provides necessary support for correct decision-making. After more than 30 years of development, the system structure of DSS started from the two-library structure originally proposed by R.H.SPRAGUE, and gradually evolved to the four-library structure that is widely used today, including the database, model base, method library, and knowledge base.

B. Structural Framework of Decision Support System of Premium Power Supply Investment

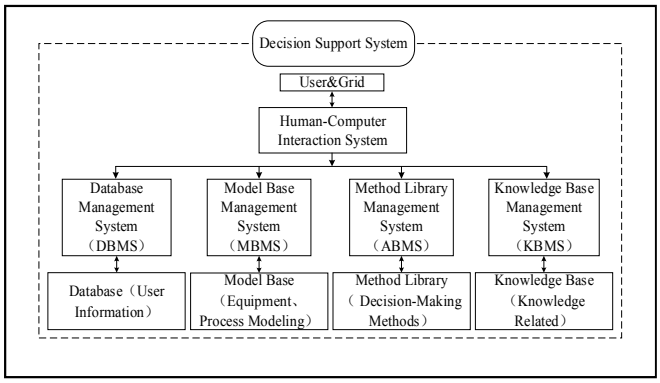

Fig. 1. *S*tructure framework of decision support system of premium power supply investment

(1) Human-computer interaction system.

It mainly implements the functions of man-machine dialogue, controlling the comprehensive evaluation process, and coordinating the communication among various subsystems. The evaluation process adopts a closed-loop structure, which can dynamically adjust and change various models in the evaluation system based on the actual results obtained in the applications.

(2) Database system.

It can use well-known database products such as Oracle, Sybase, Informix, and Microsoft SQL Server. The database management system (DBMS) provided supports basic data definition, data operation, and data maintenance functions, and has a good access interface. In the decision support system of premium power supply investment, it is used to manage and store user-related information.

(3) Model base system.

It consists of model base and model base management system (MBMS) which is responsible for the establishment, operation, maintenance and use of model base. The model can be divided into two categories, one is the standard model, the other is the industrial model established by the users.

(4) Method library system.

The method library is maintained and called by method library management system (ABMS). The method library actually stores the program codes of various basic methods involved in the evaluation process.

(5) Knowledge base system.

The knowledge base management system (KBMS) mainly implements the functions of storing, calling and inferring the knowledge of various models, methods and data in the knowledge base, and provides support for decision makers' evaluation activities.

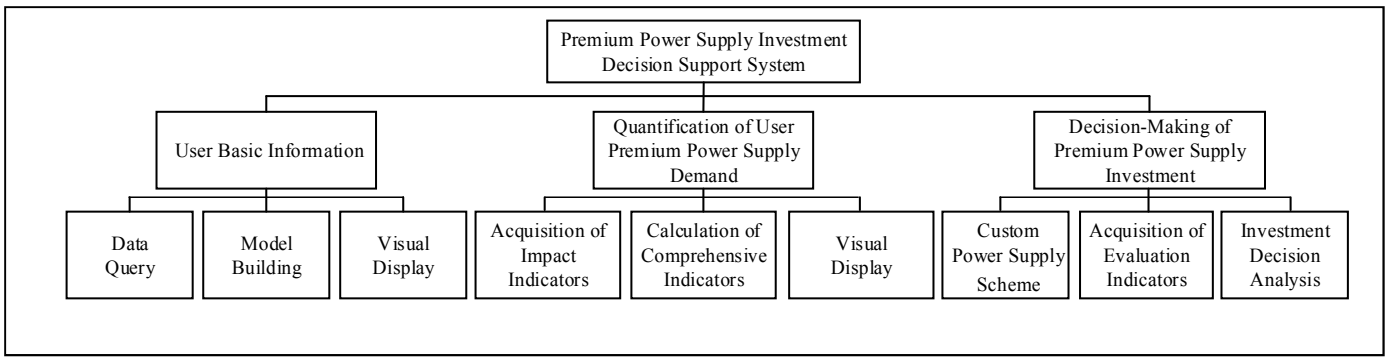

Fig. 2. Function modules of decision support system of premium power supply investment

IV. FUNCTION MODULES OF DECISION SUPPORT SYSTEM OF PREMIUM POWER SUPPLY INVESTMENT

After investigation and analysis, the system must realize the network interconnection between the power grid company and the user decision support system, establish a decision support system of premium power supply investment based on the computer wide area network, which can realize the data sharing and information transmission of the basic information of users, power quality disturbance data, user demand, premium power supply scheme, decision analysis, etc., so as to meet the needs of the power grid company in developing premium power value-added services and other aspects of demand. Therefore, this paper develops a decision support system of premium power supply investment based on premium power supply demand of users. Its function modules are shown in Figure 2, including three main function modules: input module - user basic information collection, processing module - user premium power supply demand analysis, output module – premium power supply investment scheme and decision-making. Each module provides visual statistical charts and spider diagrams, etc. to improve the information integration and visualization of the system.

A. Input Module - User Basic Information Module

The first function module of the system is used to collect user-defined data, including basic information, voltage sag history data, sensitive user model, user typical interruption loss value, etc. This kind of data supports integrity (such as the excel table) import and is stored in the system database so that analysis can be called at any time. Its main functions are as follows:

(1) The sensitive user model includes two categories: the equipment model and industrial process model. The equipment model is the Voltage Tolerance Curve (VTC) of this type of equipment. Equipment parameter settings can be achieved by changing VTC knee point coordinates. In addition, the system software supports the call of typical sensitive equipment data, that is, the typical VTC knee point values of various sensitive equipment are stored in the system, which is convenient for users to call and select. The user industrial process model is a combination of various types of sensitive equipment formed in a certain logical connection method, and the logical relationship modeling is achieved through a logical tree. The software provides a corresponding interactive interface, allowing users to set the VTC parameters of different equipment, and perform modular movement and connection operations to build the corresponding logical tree structure to achieve modeling of the user's industrial process.

(2) User-defined voltage sag history data combined with the industrial model established by the user on the previous work page can automatically generate voltage sag correlation curve scatter diagrams and statistical charts based on the obtained data, such as the F47 curve of the semiconductor industry, frequency 3D diagram and VTC scatter plot. In this way, data visualization is realized, and the original huge single data is displayed in a centralized and intuitive way in the graph, so that users can understand their own voltage sag related conditions more clearly, and provide a basis for the next step to quantify user demands.

The block diagram of the input module is shown in Figure 3.

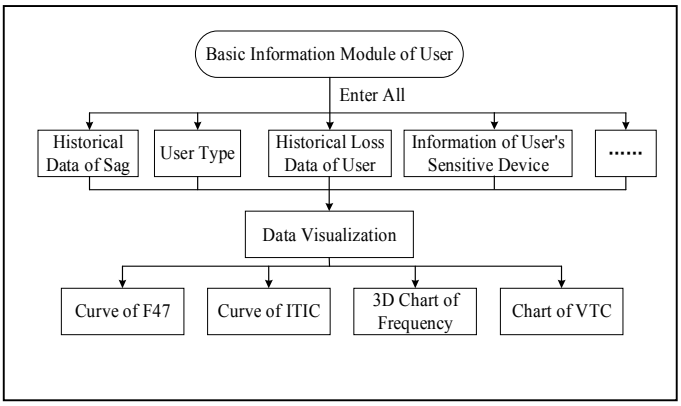

Fig. 3. The block diagram of user basic information module

B. Processing Module-User Premium Power Supply Demand Quantification Module

After the input module information is obtained, the features are extracted and the information is integrated in the processing module to realize the quantification of user demands.. The main method can use mathematical methods such as fuzzy clustering to synthesize multiple characteristic quantities that describe the user's demands, and obtain a value that can characterize the user's demands, as a judgment basis for users to adopt different

premium power supply technology solutions and investments. Similarly, this module can design a data visualization window, so that the user's demands are characterized by a color bar graph, etc., which helps users to intuitively understand their demands, and also helps the power company to adopt different premium power supply technology solutions for users.

(1) Extract 5 influencing factors to characterize the user demand of premium power supply

Power grid companies will only be interested in identifying and quantifying the demands of groups of users that grid power companies are willing to provide premium power supply. Therefore, the quantification of users' premium power supply demands includes the quantification of power quality severity levels of users and the quantification of premium power supply intentions of power grid companies. Considering the source-grid-charge three aspects respectively, the influencing factors of the user's power quality level are obtained: the grid voltage sag level, the immunity level of the equipment, and the user's acceptable status; the factors affecting the power grid company include user payment credit and user power demands. Therefore, five main factors are extracted and quantified: the sag level of the grid voltage, the immunity level of the equipment, the user's acceptable status, the user's payment credit, and the user's power demand. The results of the five influencing factors can be displayed using a spider diagram.

(2) Calculation of comprehensive index

Based on the entropy weight method, the user voltage sag level index S, user equipment immunity degree index I, and user acceptable status index C are calculated into a user perspective power quality severity level index P, and the user payment credit index H and the user power demand index E are calculated into a premium power supply willingness index W from the perspective of the grid company. After obtaining the two index values of P and W, an array value (P, W) can be obtained to represent the user's premium power supply needs. By mapping the two-dimensional comprehensive index to the coordinate axis and setting the user demand classification point according to the local power industry level, Users can be divided into 4 categories, which are low demand-weak will, low demand-strong will, high demand-weak will, and high demand -strong will. User classification shows the difference between high and low, strong and weak through color bar graph.

The block diagram of the user's premium power supply demand quantification module is shown in Figure 4.

C. *Output Module - Premium Power Supply Investment Scheme and Decision Making*

Based on the first two function modules, multiple premium power supply investment solutions are designed for the input users with demands, and feature quantities that affect investment decisions are extracted, such as user psychological feelings, utility, risk value, and investment income ratio, etc. , The image presentation methods such as spider diagrams make a direct comparison of premium power supply investment schemes, and then design algorithms to implement the premium power supply investment decision-making process, and finally output a premium power supply investment scheme that is most suitable for users.

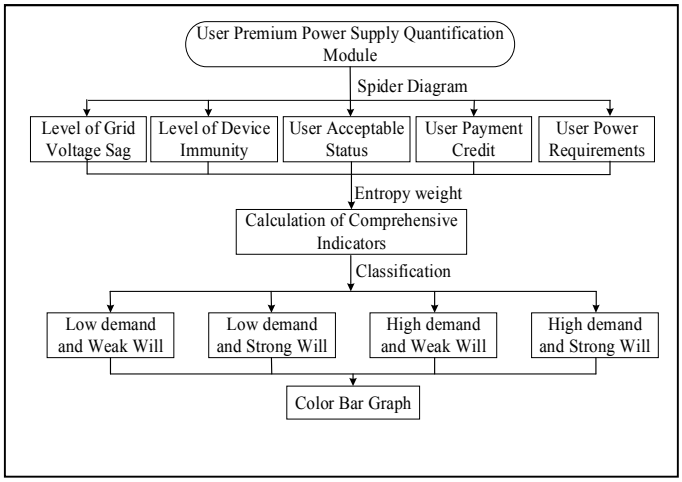

Fig. 4. The block diagram of user premium power supply demand quantification module

(1) Custom premium power supply investment scheme for users

According to the types of users' demands and basic information, the power grid company designs algorithms within the system to quickly provide users with a choice of premium power supply investment solutions A, B, C ,etc.

(2) Selection of evaluation indicators

For the premium power supply investment schemes provided, the factors that affect their pros and cons mainly come from participants, such as whether the expectations of users and power grid companies are met. Select the participant's disappointment-delight psychological feelings, perceived utility, risk value, and investment income ratio as the evaluation indicators. Through statistical calculation and analysis, evaluation spider diagrams of different premium power supply investment schemes can be obtained. The values of each indicator will be intuitively reflected in the figure. Visualize the differences of each scheme, and initially help users to select.

(3) Decisions of premium power supply investment

Based on the realization of the first two functions, the common solutions to the multi-attribute decision-making problem are used to fuse multiple index information to achieve the optimization of different premium power supply investment schemes. The system software uses algorithms to output the eigenvalues that represent the pros and cons of the investment schemes, sorts them from large to small, and obtains the decision results. In the end, the system outputs the best decision result to support the work of users and power grid company, which is simple and clear.

The block diagram of premium power supply investment decision-making module is shown in Figure 5.

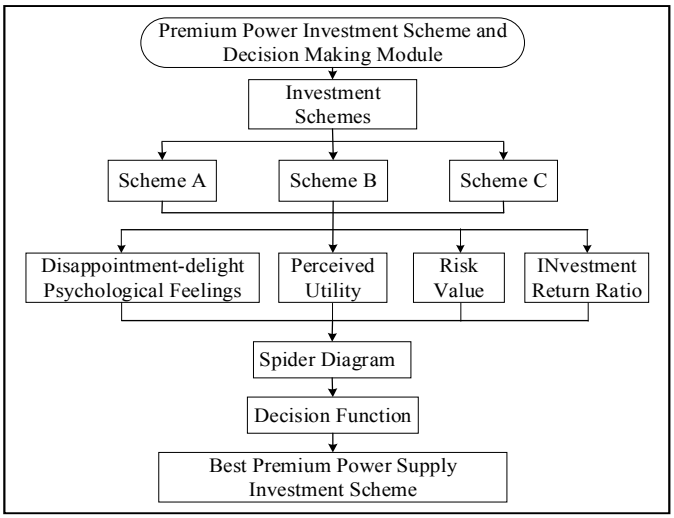

Fig. 5. The block diagram of premium power supply investment decision-making module

V. APPLICATION

The decision support system of premium power supply investment designed in this paper has been applied to a power grid company in southern China.

In the process of practical application, the decision support system of premium power supply investment shows good visibility and practicability, which can be popularized and applied in other areas to improve the level of premium power supply and user satisfaction.

Figure 6-8 below are the actual system interface diagrams.

The interface diagram of user basic information module is shown in Figure 6.

The interface diagram of user premium power supply demand quantification module is shown in Figure 7.

The interface diagram of premium power supply investment decision-making module is shown in Figure 8.

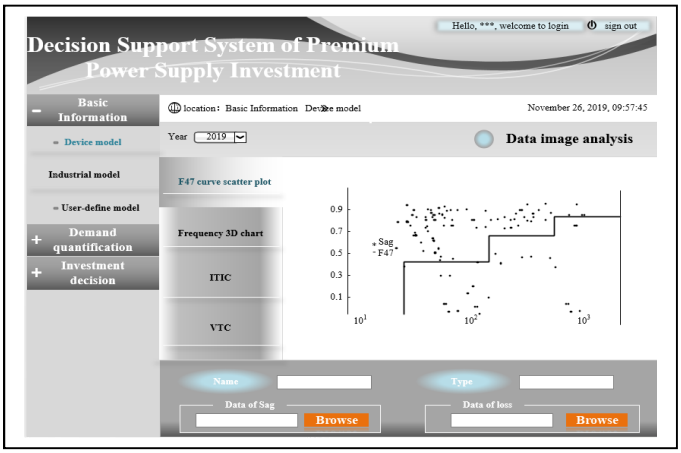

Fig. 6. The interface diagram of user basic information module

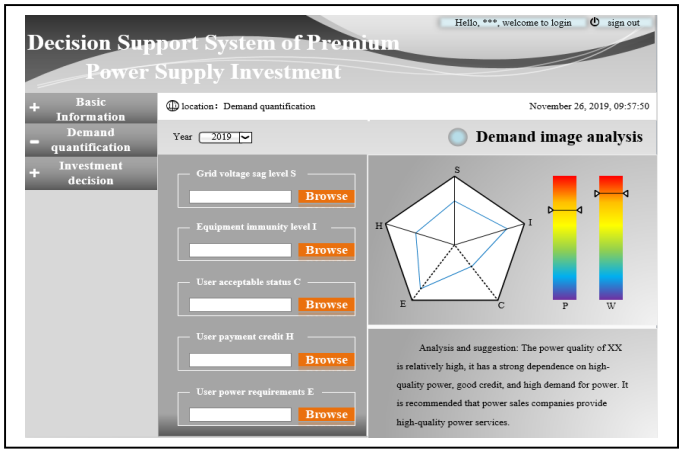

Fig. 7. The interface diagram of user premium power supply demand quantification module

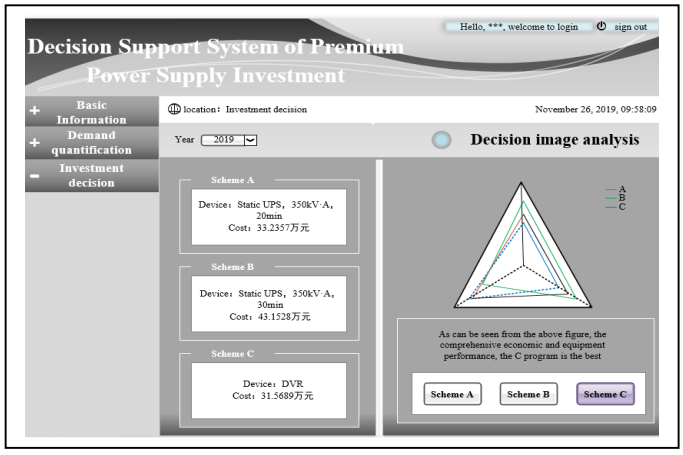

Fig. 8. The interface diagram of premium power supply investment decision-making module

VI. CONCLUSIONS

Applying a decision support system to carry out research on decisions making for premium power supply investment is an important solution to improve the efficiency and effectiveness of premium power supply value-added services. Among them, accurately identifying the premium power supply demands of sensitive users with voltage sags and providing the best premium power supply investment scheme are important guarantees for the smooth development of premium power markets. This paper proposes a decision support system of premium power supply investment based on user premium power supply demands. Through empirical analysis, the effectiveness of the developed system is proved, and the following conclusions are obtained.

(1) There is no research on the decision support system of premium power supply investment at home and abroad. This paper is original.

(2) In the era of big data, different users have different needs, and sensitive equipment are different. This means that large users have premium power supply related information. Through the design of the demand quantification function of the decision support system of premium power supply investment, a large number of tedious user data is effectively organized, presented, and used to achieve good user classification.

(3) The decision support system of premium power supply investment designed in this article can integrate and process multiple types of information, store and present it in a single system, and associate multiple function modules to provide a complete set of premium power supply information. The premium power supply technology is more intelligent and integrated, which avoids the complex collection of multiple types of premium power supply technology. This is convenient and efficient for users and power companies.

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