Multidimensional Data Model and Analysis Method of Economic Operation in Distribution Network

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ABSTRACT

In view of the fact that current economic management of distribution network is mostly confined to the study of economic evaluation index and lacks some means to carry out in-depth analysis and excavation of the key influencing factors of distribution network economic operation, this paper presents a multidimensional data analysis distribution network economic operation practical method. By establishing a multidimensional analysis model of economic operation of distribution network, this paper comprehensively analyzes historic economic data of distribution network and various factors from multi-aspects, multi-perspectives and multi-levels to deeply mining the potential of energy-saving and loss reduction of distribution network.

Keywords: Distribution network, economic operation, influencing factors, multidimensional analysis

INTRODUCTION

With the progress of electric power reform, electric power enterprises pay more attention to the improvement of economic operation of power grids in pursuit of higher economic benefits. During the operation of the power system, the power is transmitted to the user side through power generation, transmission, substation and power distribution. This process consumes a large amount of power, and the power loss of the power distribution link accounts for more than half of the power loss of the entire power grid. Therefore, the economic operation of the network is of great importance to reduce the network loss of the entire power system. In current researches on distribution network economics, Ma Liye [1], Ding Rongrong [2] and Shi Yong [3] pay attention to the updating of evaluation indexes, Ma Cuiping [4] and Zhan Xuedan [5] focus on the improvement of algorithms, which are limited to analyzing the operation data of distribution networks, seldom considering weather, Environment and other factors on the distribution network economy. Song Shenghe [6], Jiang Lizhen [7] and Wang Ping [8] proposed that with the distributed power, electric

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vehicles large-scale access to distribution network, power grid and user interaction increasingly frequent supply and demand, distribution network structure, control methods and operating conditions have undergone significant changes in intermittent and uncertain energy source with the match. The impact of grid loss on power grids poses a tremendous challenge to the economical operation of smart distribution networks. Multidimensional analysis technology is also called online analytical processing (OLAP). In this paper, the OLAP technology widely used in the commercial field is applied to the economic analysis of the distribution network. Based on the economic historical data of the distribution network and the integration of various factors, conduct multidimensional analysis on the power generation characteristics of distributed generation, electric vehicles and flexible loads to find out the factors that limit the economic improvement of the distribution network and make timely improvements to take corresponding measures to effectively support the current distribution network economic operation.

**DISTRIBUTION NETWORK ECONOMIC OPERATION DATA MULTIDIMENSIONAL ANALYSIS AND MODELING**

The multidimensional data model consists of a dimension set and a hierarchical set of metric indexes, which determine which analysis operations can be performed on the data and which data observation angles are available, which is the basis for multidimensional data analysis [9].

This paper analyzes the historical data of economic operation of distribution network from multiple dimensions of time, space, user and reason considering the characteristics of network structure, equipment technology status and power consumption composition of various voltage distribution network, distribution multidimensional economic analysis model, as shown in Figure 1.

![Economical Multidimensional Analysis model of Distribution Network.](image)

In the multidimensional economic analysis model of distribution network, there are 6 first-level dimensions and 3 metrics. Among them, the time dimension is divided into years, quarters, months, days, hours, divided into six levels; space dimension refers to the distributed power generation and network location of provinces, cities and counties distributed power stations three levels; the number of users, the type of users and the amount of electricity consumed. The types of users are divided into four levels: large industrial users,
general industrial and commercial users, agricultural users and residential users. The voltage 
levels are divided into high, medium and low voltage levels. The reason dimension is divided 
into two levels, the reason category includes external forces, environment, weather and DG 
factors. The DG factors are divided into DG access locations, DG capacities and DG 
operation modes. Economic analysis of distribution network is mainly to analyze the factors 
that lead to line loss, distribution line loss can be obtained by subtracting the amount of 
power supply and power supply, so the total power supply, power consumption, and the 
difference between the two "distribution network loss" as a measure of value. Due to 
distribution network access to large-scale distributed power supply, power supply referred to 
in this article refers to the sum of power supply data measured from the substation gateway 
and distributed generation power grid connection. Economic multidimensional analysis of 
distribution network formula, as shown in equation (1).

\[ M,D=(D,M), \\
D=[d_{time},d_{space},d_{users},d_{line loss location},d_{reason},d_{voltage level}], \\
d_{time}=[\{ \text{hour,day,month,year,}d_{time-all} \}, \text{hour} \leq \text{day} \leq \text{month} \leq \text{year} \leq d_{time-all}], \\
d_{space}=[\{ \text{county,city,province,}d_{space-all} \}, \text{county} \leq \text{city} \leq \text{province} \leq d_{space-all}], \\
d_{users}=[\{ \text{resident users,agricultural users,general business users,large industrial users,}d_{users-all} \}, \text{resident users} \leq \text{general business users} \leq \text{large industrial users} \leq d_{users-all}], \\
d_{line loss location}=[\{ \text{element,equipment,line,}d_{line loss location-all} \}, \text{element} \leq \text{equipment} \leq \text{line} \leq d_{line loss location-all}], \\
d_{reason}=[\{ \text{specific reason,reason category,}d_{reason-all} \}, \text{specific reason} \leq \text{reason category} \leq d_{reason-all}], \\
d_{voltage level}=[\{ \text{low voltage,medium voltage,high voltage,}d_{voltage level-all} \}, \text{low voltage} \leq \text{medium voltage} \leq \text{high voltage} \leq d_{voltage level-all}], \\
M=[\text{power supply,energy used,}d_{\text{line loss}}].
\]

Where: \( MD \) is a multidimensional data model; \( D \) is a dimension set, which contains 
several dimensions \( d \); each \( d \) also includes several layers, \( \leq \) denotes the hierarchical 
relationship between the layers (left below the right) The higher the degree of synthesis of the 
data; \( d\text{.all} \) layer is an additional level introduced to select all the data, is the highest layer in 
each dimension; \( M \) is the index set, contains a number of indicators.

**DEEP MINING THE ENERGY SAVING POTENTIAL OF THE DISTRIBUTION NETWORK BASED ON THE OLAP TECHNOLOGY**

After the establishment of economic multidimensional data model of distribution 
network, according to different analysis objectives, the data's observation dimension and 
corresponding measurement index are determined. The factors that limit the economic 
increase of distribution network are analyzed by OLAP technology, and the energy saving of 
distribution network is deeply tapped the potential of loss reduction, from the economic point 
of view to improve the economic operation of distribution network provide the basis for 
decision-making.

This case studies and analyzes the influencing factors of economic operation of 
distribution network with distributed power supply and electric vehicle access. The distribution 
network users to large industrial users, there are 10 distributed power and 
network access, access to distributed photovoltaic 12.5MW, wind power 5.55MW, a total of 
18.05MW.
Multidimensional analysis not only can analyze different dimensions, but also can carry on the matching analysis of different levels of data in the same dimension. In practical application, each multidimensional analysis does not pay attention to all the data, all the dimensions, levels and metrics. Instead, it conducts in-depth mining analysis after reconstructing the economic multidimensional analysis model of distribution network according to actual demand. Based on the reconstructed multidimensional data model, the basic operation of multidimensional analysis such as slicing and dicing, drilling and drilling, unfolding and shrinking, flipping and the like can be performed on economic data related to distribution network. Among them, the slicing and dicing operations focus the area of interest by reducing the area of the multidimensional analysis; the drilling and drilling operations change the data granularity in the multidimensional analysis to perform shallow trend analysis and deep data exploration. The granularity analysis can find the problem well. The expansion can integrate the measurement attributes and the aggregation into the comprehensive analysis. The contraction reduces the unnecessary measurement and aggregation, simplifies the view and helps to focus analysis [10]. This case only retains the time dimension, user dimension and reason dimension, and the measurement index considers the amount of power consumption and the distributed power generation grid connection.

**Electricity Consumption Slice On User Type Axis**

In order to analyze the effect of user types on power consumption, a user-level slice analysis is performed starting from the user dimension and using the power consumption as shown in Figure 2. Among the four major electricity consumption categories in 2017, large industrial electricity consumption has the greatest impact on the total local electricity consumption, while the contribution of general industrial, commercial and residential electricity to electricity consumption growth and pulling rate are larger.

![Figure 2. Slice Result on User Type Axis with Power Consumption.](image)

**Electricity Consumption Timeline Slice Analysis**

In order to analyze the changes of power consumption in different time periods, the paper starts from the time dimension and uses electricity consumption as a measure to segment the quarterly levels and analyze the trend of electricity consumption in each quarter in depth, as shown in Figure 3.
The annual temperature gradually rises after June. Since July 2017, there have been many consecutive high-temperature hot weather, of which 35 days at high temperature of 23 days, 37 degrees Celsius heat of 16 days, 40 degrees Celsius extreme heat for 3 days. When the air temperature rises, people cool down the air by turning on the air conditioners, fans, refrigerators and other appliances, leading to a sharp rise in power consumption. The slicing analysis on the timeline of the power consumption can predict the power consumption based on the predicted air temperature in the future.

**Distributed Generation Timeline Slice Analysis**

In order to analyze the changes of grid-connected generation of distributed generation in different time periods, this paper analyzes the quarterly levels by using the time dimension and the grid-connected amount of distributed generation as a measure to analyze the trend of distributed generation in each quarter, as shown in Figure 4.

Figure 4 shows the generation of grid-connected power generation in different quarters. It can be seen that there is significant correlation between the amount of grid-connected power generated by distributed generation and the season. The distributed power supply in this case mainly includes photovoltaic power generation and wind power generation. In winter and spring, wind power generation with strong wind power generation is high and the amount of light and high photovoltaic power generation in summer is high, which is consistent with the above analysis results.
Distributed Generation Grid Connection in Time and Space on the Axis of the Dicing Analysis

In this paper, the time and space dimensions are used to analyze the grid-connected quantity of distributed generation and power generation, as shown in Figure 5. Among them, the space dimension mainly considers the location of the distributed power grid-connected points, and X in the figure represents the ratio of the distance between the distributed power source and the substation in the total length of the line.

Figure 5. Distributed Power Generation and Grid Connection in the Time Axis and the Spatial Axis of the Dicing Analysis Results.

CONCLUSION

The economic operation of distribution network is an important guarantee to ensure the quality of power supply and service. In this paper, the multidimensional data analysis method is used to comprehensively analyze the economical historical data and various factors of distribution network, dig out the factors affecting the economic operation of distribution network, analysis of changes in historical data and trends, energy-saving measures can be targeted to reduce losses, in order to optimize and transform the distribution network to provide detailed and reliable theoretical basis for supporting advanced applications such as coordination and control to improve the economic efficiency of power enterprises and Social benefits have important theoretical and practical significance.

REFERENCES