# Big Data Impact Analysis of Smart Grid based on AHP method

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**Abstract.** With the rapid development of smart grid, the using of smart appliances, the new information system and the application of digital work gradually get into the smart grid companies. It provides a digital basis for the big data technology to enhance smart grid's service capabilities, which is the inevitable trend of the development of the smart grid. In this paper, a scientific, systematic and objective evaluation on the smart grid's impact of the big data technology is created with a total of fourteen indicators from three aspects: technology, smart grid status monitoring and simulation, the weights of the indexes are given by using the AHP. From the results analysis, the relevant suggestions are given in the three aspects of the integrating intelligent electronic components, enhancing the big data load forecasting and real-time data monitoring capabilities.

## Introduction

With the rapid development of smart grid and the application of the Internet, cloud technology, mobile technology and other new technologies, the dependence on informatization of industrial production is becoming stronger and stronger. The new information system and the application of digital operation gradually get into the power enterprise, and it's not only a good opportunity for the development of smart grids, but also a severe challenge. With the China National State Grid putting SG186 project into operation and starting SG-ERP construction, the business activities including production, operation and management are increasingly dependent on the information system. With the business data storage in nearly ten years, the China National State Grid has gathered a large amount of data, which is given a basic chance of big data analysis, and then to provide the basis to improve the level of smart grid's service approaches.

Nature and Science respectively launched special issues of big data in 2008 and 2011, respectively Big Data and Dealing With Data, introduced the challenges of big data bringing from the network, super computing, Internet and so on. The issues also pointed out if the large data mining technology gets further development, people will be able to get more opportunities from get hidden information, so as to make the information science technology play a great role in promoting the development of society[1-2]. Smart grid, formed by highly integrated technologies including the information technology, computer technology, communication technology, the original transmission and distribution infrastructure, is a new type of grid. It has the advantages of improving energy efficiency, security of power supply, reducing environmental impact and the reliability of power supply of transmission network[3-4]. The idea of the smart grid is to get more users' information about how to use electricity, so as to optimize the production, distribution and consumption of electricity and use modern network to communication and information technology to carry out mass exchange of information, and then to realize the information exchange between the smart grid equipment and automatically complete the basic functions of information collection, processing, measurement, control, protection, measurement monitoring and so on[5]. It depends on the need to support the smart grid real-time automation control, intelligent regulation, online analysis and collaborative interaction and other advanced functions[6], so the smart grid provides a good basis for the application of big data. At present, the application of big data in smart grid has been studied in the field of smart sensor, electricity price forecasting, power load forecasting and so on. The application of big data analysis will

 

have a profound impact on the Power Grid Corp, but it has not been found any research about the impact of big data analysis technology on the Power Grid Corp so far.

This paper analyzes the impact of big data analysis on the power grid company and constructs the impact index system of big data development under the smart grid environment, then use the AHP to evaluate and analyze the research, with the results, the references for the construction and development of big data analysis are given for the smart grid development.

## Impact analysis of big data technology in Smart Grid

**Impact analysis**. The evaluation system of the big data technology of smart grid technology impact indicators as follows:

Table 1 Impact assessment index system of big data technology in Smart Grid

| Objective layer | Criterion layer | Third level indicators |
|---|---|---|
| Impact of big data technology in Smart Grid | Technology influence ( B1 ) | Real time data acquisition |
| | | Data control integration performance |
| | | Data monitoring capability |
| | | Data simulation capability |
| | Grid state monitoring effect ( B2 ) | Data identification capability |
| | | Status monitoring capability of electrical apparatus |
| | | Real-time data monitoring capability |
| | | Power quality service analysis |
| | | Fault repair capacity |
| | Simulation influence ( B3 ) | Smart grid topology simulation calculation |
| | | Load forecasting capability |
| | | Power flow analysis ability |
| | | Tacit knowledge analysis and decision making ability |
| | | Distributed computing ability |

**The principle of AHP**. Analytic hierarchy process (AHP) is an effective method to deal with how to convert the complex and ambiguous relations to quantitative relationship, which is proposed by the American scholar T.L.Saaty. Using the AHP method to determine the weight of the indicators is as follows:

(1) Establish pairwise comparisons judgment matrix

First of all, establish the judgment matrix $U$ by comparing the elements one by one, in the matrix, $u_{ij}$ is the importance proportion criteria of $U_i$ and $U_j$ for $X$ . And the values of proportion criteria can be seen in Table 2.

Table 2. The meanings of judgment matrix proportion criteria

| Proportion criteria | Meanings |
|---|---|
| 1 | The importance are equal between these two elements |
| 3 | One of the two elements is slightly more important than the other |
| 5 | One is more important than the other |
| 7 | One is much more important than the other |
| 9 | One is extremely more important than the other |

Then, calculate the index weights in each hierarchy. The steps are as follows:

1) Calculate the product $M_i$ of each line elements of judgment matrix

$$M_i = \prod_{j=1}^{n} x_{ij}, i = 1,2, \mathbf{L}\ n \quad (1)$$

2) Calculate the n-th root of $M_i$

$$W_i = \sqrt[n]{M_i} \quad (2)$$

3) Normalize the vector $W$

$$W=Wi/sum(W) \quad (3)$$

Then, the vector $W = [W_1, W_2, \mathbf{L}\ , W_n]^T$ changes to be the eigenvector (weights).

However, it is impossible to ensure the absolute consistency when the elements are comparing with each other. Thus, to keep the reliability of Analytic Hierarchy Process, the consistency of the judgments must be checked after normalizing. And the checking steps are as follows:

(2) Calculate random consistency index $CI$

$$CI = \frac{l_{\max} - n}{n-1} \quad (4)$$

In the formulas, $n$ is the judgment matrix order, while $\lambda_{max}$ is the largest eigenvalue of the judgment matrix.

(3) Calculate consistency ratio $CR$

$$CR=CI/RI \quad (5)$$

In the formulas, $RI$ is an average random consistency index, which can be queried in the RI index table. The consistency of the judgment matrix can be accepted when $CR < 0.1$. If not, the appropriate modification of the judgment matrix is needed until the consistency can be accepted.

(4) Define a candidate set $X = \{x_1, x_2, \mathbf{L}\ x_i, \mathbf{L}\ x_n\}$, and an evaluation score matrix $R$. Combined with the weights calculated in the above step, the final comprehensive evaluation result can be gotten.In accordance with the above evaluation method as well as the method of determining the index value, also according to the actual situation, the analysis and evaluation of the big data and demonstration project of the smart grid at China's provincial level is carried out, the calculation process and results can be listed in Table 3.

Table 3. The evaluation results of big data platform influences in three China's provinces

| Object Level | Indicators | Final weight | Province A | Province B | Province C |
|---|---|---|---|---|---|
| Impact assessment of smart grid construction | Real time data acquisition | 0.095 | 61 | 70 | 69 |
| | Data control integration performance | 0.173 | 68 | 72 | 64 |
| | Data monitoring capability | 0.033 | 67 | 65 | 68 |
| | Data simulation capability | 0.033 | 62 | 72 | 61 |
| | Data identification capability | 0.023 | 63 | 71 | 62 |
| | Status monitoring capability of electrical apparatus | 0.088 | 61 | 65 | 61 |
| | Real-time data monitoring capability | 0.088 | 63 | 65 | 63 |
| | Power quality service analysis | 0.088 | 70 | 68 | 69 |
| | Fault repair capacity | 0.046 | 63 | 72 | 64 |
| | Smart grid topology simulation calculation | 0.029 | 66 | 67 | 70 |
| | Load forecasting capability | 0.053 | 66 | 67 | 66 |
| | Power flow analysis ability | 0.053 | 66 | 72 | 68 |
| | Tacit knowledge analysis and decision making ability | 0.099 | 69 | 70 | 66 |
| | Distributed computing ability | 0.099 | 66 | 68 | 63 |
| | Total | 1 | 65.51 | 68.97 | 65.14 |

From the results of the calculation, because the construction of smart grid in China is still in the early stage, the impact of the general big data integration is still weak, and it is in good level. On the score, the impact is in the initial stage, has not yet formed a more far-reaching impact. It gets low score in intelligent electronic components, integrated load forecasting ability, real-time data monitoring ability and so on. To further improve the impact of large data in China's smart grid, we need to further strengthen the construction of smart electronic components and other data feedback source. In addition, for the distribution of computing power, the big data platform needs to combine with cloud computing technology to form a distributed computing platform, so as to work better with the analysis capabilities of big data.

## Conclusions

In this paper, the impact of big data development in China's smart grid is studied. The impact of the big data development in China's smart grid is a total of 14 indicators from three aspects: technology, smart grid status monitoring and simulation. Also the weights of the indexes are given by using the AHP. An empirical analysis of the development of China's national smart grid corporation at the provincial level by using the method of expert investigation is also conducted. Through results of the analysis, the relevant differences are given as well as the advice that the development of big data in the smart grid needs to be further strengthened.

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