Design of coupling monitoring model for operation state of new energy station based on Data Mining

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Abstract: The development of modern technology has put forward new requirements for the monitoring methods and equipment modernization of new energy power stations in China. As an important part of the construction of new energy, the monitoring method of the new energy station should be designed according to its future development plan to meet the needs of safe use in the new energy station and ensure the healthy operation of the new energy station. In order to meet the above requirements, a data mining-based coupling monitoring model design for the operation status of new energy stations is proposed. Combining modern new energy station monitoring planning and design, this paper develops monitoring models in the construction of new energy stations, promotes the development and optimization of new energy station monitoring design, and applies dynamic monitoring models to the construction of new energy stations to ensure the safe operation of the station.

1. Introduction
In recent years, with the large-scale development and utilization of new energy in our country, the operating pressure of new energy plants has increased. While enjoying convenience and cleanliness, the new energy field station model pays more attention to operational safety and strives to solve technical problems. Therefore, the design of a coupled monitoring model for the operation status of new energy stations based on data mining is proposed. The design of the new energy station safety monitoring management mode requires long-term effort and innovation. It needs to be continuously improved and improved in the practice of virtual monitoring technology in the application of new energy stations to ensure the safe and stable operation of the new energy station and make it more Meet the actual needs of society and improve the quality of life of urban residents. Therefore, the construction of the supervision model has always been the focus of the construction of new energy stations[1]. Combine the concepts of environmental protection, energy saving, and high efficiency with virtual monitoring technology to establish a new energy station monitoring mode to provide efficient and scientific planning, design and technical support for the construction of new energy stations. Based on the analysis of the current status of the coupled monitoring model for the operation of new energy fields and stations, on the basis of the WebGIS development platform, a dynamic synchronization mechanism for new energy basic information and an operation data aggregation mechanism have been established, and an open quasi-real-time model for three fields has been
constructed software platform. Comprehensively analyze, manage and display the basic data of new energy generator sets, and visually manage important data to achieve accurate monitoring of the operating status of new energy plants\(^2\)\(^{-}\)\(^4\).

2. Coupling monitoring model of new energy station operation state

2.1. New energy station operation status monitoring framework

In order to better apply the dynamic monitoring mode to the daily management of new energy stations, standardize the behavior of new energy stations, realize on-site dynamic monitoring and data extraction of new energy stations, and measure all monitoring points of new energy stations with data mining technology. Using the latest equipment's three-dimensional imaging technology to form virtual simulation scenes and high-precision models, connect the monitoring data to the existing new energy field station information model, obtain the monitoring data of each model online in real time, and simulate the scene to perform real-time data in the station. Record and check related equipment to meet the needs of safe and efficient operation, data monitoring and accident prevention, ensure real-time monitoring of the operating status of new energy plants, and ensure the modern operation of new energy plants. Based on the monitoring and analysis of the operation status monitoring access point of the new energy field and station, combined with the relevant parameters of the new energy network, the new energy unified dispatch panorama model determines the complete attributes of the target objects of various new energy equipment, establishes and divides New energy logical partitions provide more intuitive information for the operation and management of new energy\(^5\)\(^{-}\)\(^7\). In order to realize the collection, sorting, maintenance and uploading of basic data under the dispatch automation mode of the province, as well as the dynamic synchronization and collection mechanism of business data between the inter-provincial modes, the design idea of "source-end maintenance, network-wide sharing" is proposed. According to the chart display, the new energy field station operation status monitoring framework structure is displayed, as shown in Figure 1:

![Figure 1](image)

Three base data modeling of new energy

Model synchronization and data collection

Basic model

Network related parameters

management information

Operation analysis

Power prediction

Historical storage

Panoramic modeling

region

Station

equipment

Access point

section

transaction

Based on the above structure, the three-dimensional imaging technology is further used to establish a high-precision virtual simulation scene model, and seamlessly connect with the monitoring data information model of each energy station\(^8\). Each model is processed and analyzed through the information center model, and the monitoring data of each model is online in real time. Based on the mathematical model and normal distribution data, the dynamic characteristics analysis model of the new energy field station is established. Based on this model, the next time dynamic simulation scene and high-precision model of the new energy field station are studied. The model enables us to obtain preliminary results in the laboratory or on the computer, so as to obtain the best compensation
measures or emergency plans. Using this model can save a lot of resources and improve the efficiency and time of security control. Using this simulation model, staff can also perform equipment inspection, maintenance training and work assessment in the simulation scenario, which greatly improves work efficiency, shortens the work cycle, and reduces the safety risk of station operation. Figure 2 shows the information processing framework for monitoring the operation status of new energy plants [9].

Based on the above framework, real-time storage and processing of operating status monitoring information are carried out, and massive detection information is obtained for screening and detection. Through the processing of database, access, management, comparison, processing, calculation, storage and other components, the design of the processing mode of the information center is realized [10]. The unity and cooperation of various departments constitute the processing mode of the information center, which processes and manages the collected data, and completes the exchange, comparison and feedback of various data information. It integrates management, interaction, processing, storage, and forwarding to ensure the stability, security and reliability of the processing method of the information center. Then view all historical monitoring data through program control, provide various statistical data, and respond to alarm information in time. This mode realizes the clustering of the safety monitoring and management of new energy stations, which is equivalent to the front-end analysis based on the specific professional plan based on the preliminary processing of each module to remove the accurate and effective data information required by the front-end [11-13].

Figure 2  information processing framework of operation status monitoring of new energy stations

2.2. Data mining for coupling monitoring of new energy stations

By using artificial intelligence and neural network and other scientific means, the relationships, patterns and trends with potential, implicit, previously unknown and potential value are mined out from the massive operation state data of new energy stations, and these knowledge and rules are used for modeling, so as to provide operation state prediction of new energy stations and provide decision-making services for operation of new energy stations [14]. The goal of data mining is to generate knowledge and model according to the meaning expressed. To determine the potential energy consumption mode by clustering analysis, it is necessary to extract the inverse signal from the energy consumption time series data, and calculate the image energy consumption based on the eigenvector: average hourly consumption of cavg, maximum hourly consumption of cavg, i.e., D=(cavg, Cmax).

Assuming that the operation state coupling characteristic the new energy station is k, then:

\[
\hat{y}_i = k \sum_{i=1}^{K} f_i (x_i), f_i \in F
\]

(1)
Among them, \( f \) is the \( k \) data feature, \( x_i \) is all the characteristics of the data:

\[
\text{Obj}(\theta) = \sum_{i=1}^{n} l(y_i, \hat{y}_i) + \sum_{k=1}^{K} \Omega(f_k)
\]

\[
\text{Obj}(t) \approx \sum_{i=1}^{n} \left[ g_i w_{q(x_i)} + \frac{1}{2} h_i w^2_{q(x_i)} \right] + y T + \frac{1}{2} \lambda \sum_{j=1}^{r} w_j^2
\]

\[
= \sum_{j=1}^{r} \left[ \left( \sum_{i=1}^{n} g_{ij} \right) w_j + \frac{1}{2} \left( \sum_{i=1}^{n} h_i + \lambda \right) w_j^2 \right] + y T
\]

Suppose the objective function is the following equation:

\[
\text{Obj} = \sum_{i=1}^{n} l(y_i, \hat{y}_i)
\]

After deleting all constant terms, the \( l \) element of the objective function is obtained:

\[
\text{obj}^{(i)} = \sum_{i=1}^{n} \left[ g_i f_i(x_i) + \frac{1}{2} h_i f_i^2(x_i) \right] + \Omega(f_i)
\]

Further calculation of energy consumption index formula is as follows:

\[
MSCON_1 = 1000 \text{obj}^{(i)} (MSIN_1 + MSIN_2 + MSIN_3 + MSIN_4)
\]

\[
MSCON_2 = 76 \text{obj}^{(i)} MSIN_5
\]

\[
MSCON_3 = 9.2MSIN_7 + 0.1MSIN_8 + 2.3MSIN_9 + 0.17MSIN_{10} - 0.8MSOUT_1 - 0.8MSOUT_2
\]

Where \( MSIN_1 \) is the minimum energy consumption, \( MSIN_2 \) is the safety of energy operation, and \( MSIN_3 \) is the total energy consumption. Through the establishment of monitoring indicators, the monitoring indicators of different media energy consumption are determined in the model layer, and the energy statistics are carried out in a certain period of time. The total energy consumption of all kinds of energy sources is reflected in the comprehensive energy consumption after the calculation\(^{[15]}\). Energy consumption is large and comprehensive energy consumption is high, but it can not reflect the level of energy utilization. Based on this, the EC model of comprehensive energy consumption of atmospheric and vacuum distillation unit was established on the basis of energy-saving monitoring

\[
EC = \sum_{i=1}^{10} \text{ASIN}_i \ast RS_i - \text{ASOUT}_1 \ast RS_{a1} - \text{ASOUT}_2 \ast RS_{a2}
\]

\[
= \text{ASCON}_1 + \text{ASCON}_2 + \text{ASCON}_3 + \text{ASCON}_4
\]

\( ASOUT \) is the energy consumption of each energy medium in the atmospheric and vacuum distillation unit. \( RS_{a1} \) and \( RS_{a2} \) calculate the energy consumption rate of each energy medium respectively\(^{[16]}\). Based on the definition of energy efficiency, the following indexes are defined as the energy efficiency evaluation indexes of atmospheric slag yard.

\[
ESS = \frac{\sum_{i=1}^{13} \text{ASP}_i}{EC - ES}
\]

\( ESS \) is the energy efficiency model of atmospheric and vacuum distillation equipment, which is the energy consumption output per unit product. In order to evaluate the use effect of various energy media, four unit consumption indexes are proposed: unit crude oil equivalent equivalent, unit crude oil...
steam equivalent equivalent, unit crude oil energy consumption monitoring data and unit crude oil energy consumption monitoring data.

\[
ESFUE = \frac{ASCON_1}{ESS + ASM_1}
\]  

(10)

\[
ESSTR = \frac{ASCON_2}{ESS - ASM_1}
\]  

(11)

\[
ESELE = \frac{ASCON_3}{ESS - ASM_1}
\]  

(12)

\[
ESWAT = \frac{ASCON_4}{ESS + ASM_1}
\]  

(13)

Based on the above algorithm, the meteorological conditions, data information, images and other information of the new energy station site are collected and stored, and the alarm information is received and sent in real time, and the sensor data is collected and transmitted through the network[17]. To achieve 24-hour monitoring image, alarm prompt, data acquisition and other functions. In the monitoring area, real-time acquisition of high-definition video images is convenient for managers to view and master the dynamic situation of each period at any time. Any abnormal and dangerous factors can be detected by video monitoring technology[18]. On the basis of information collection, the dynamic monitoring model is used to transmit information, and the detection modules of pipeline components such as pipeline leakage detection module, rail edge detection module, ground label detection module, ground environment monitoring module along the pipeline, pipeline valve, flange, compensator and other pipeline components are established, and the maintenance module of new energy equipment is added. In the process of information transmission, pre-classification analysis and pre-processing of field conditions[19]. According to the actual situation of the new energy station, it reduces the wiring difficulty, reduces the cost, and is not easy to be damaged, reduces the maintenance cost, can be flexibly reused, can accurately and quickly transmit to the information center processing mode, reduce the cost investment and labor cost. Basic data management mainly includes the management and maintenance of static data, and the statistics and maintenance of historical basic data of new energy. Including: management and maintenance of new energy static data, statistics and maintenance of new energy historical basic data[20]. Based on the new energy data collection, the collected data are classified, integrated, displayed in real time, and analyzed statistically. Based on the idea of panoramic modeling, real-time statistical analysis of the operation data of "area field" equipment in different spatial dimensions is carried out. Based on this, the operation status monitoring information processing steps of new energy stations are optimized as Figure 3:

![Figure 3  operation status monitoring information processing steps of new energy stations](image)

Energy efficiency data is the basis of energy efficiency management and the key to decision analysis, and it is also an important means to provide external services. With regard to energy
efficiency, people have conducted extensive research on energy efficiency structure. The study of energy consumption structure can understand the new energy behavior of users, provide data support for the government to formulate policies to respond to demand and orderly new energy, analyze and excavate new energy data, analyze and excavate national industrial prosperity index, analyze economic development trend, provide basis for the government to formulate macro-economic policies, and understand user needs Help with production planning. Through data collection, it is more convenient to update, add, delete and modify the data. The data is loaded into the dataset by the application to provide the cache required by the application, and then the data is used to read and use the temporarily stored data. Dataset also has maintenance function, which can maintain data changes and so on. After the data is updated, the tracker also changes. Used to display the customer database. Data information is combined with Binding Source data group and Data Grid View control through dam, which provides intuitive and convenient data display, and has the ability to add, find, save and delete data. Based on the above analysis, the data processing framework is optimized, as shown in Figure 4.

Based on the above steps, the coupling monitoring of the operation status of new energy stations can better process the massive data and ensure the transformation and scientificity of the operation status monitoring of the stations.

Figure 4  data collection service management framework of monitoring model

2.3. Implementation of coupling monitoring for operation state of new energy station

| classification | performance monitoring index of station operation state |
|----------------|--------------------------------------------------------|
| Static page class | Static page class  | Response time ≤ 1s |
| Transaction processing | Common response class | Response time ≤ 5s |
| | Cross system response class | Response time ≤ 10s |
| | Small amount of data simple query class | Response time ≤ 2s |
| Query class | Complex multiple query classes with small amount of data | Response time ≤ 5s |
| | Batch data simple query class | Response time ≤ 10s |
| | Cross system query class | Response time ≤ 15s |
| | Complex analysis query class | Response time ≤ 15s |
| Statistics | Fuzzy query class | Response time ≤ 10s |
| | Simple statistics | Response time ≤ 10s |
| | Complex statistics | Response time ≤ 30s |
Based on the evaluation and analysis of the operation and dispatching of the new energy plant and network, the new energy plant and network energy consumption evaluation system was further constructed. Based on the panorama of new energy related fields, it mainly includes the analysis and evaluation of new energy consumption, the automatic generation of energy consumption analysis reports, etc., to realize the basic management information of the operating status of new energy plants, related operating parameters, equipment operating status, etc. Information is effectively monitored and unified scheduling, etc., and the display of regional thematic information is realized through fragmented data. According to the requirements of new energy standard operation and management, the dynamic generation, intelligent verification and automatic reporting of new energy daily operation reports are realized, the definition of statistical indicators and statistical methods of the standardization of the report, the report is classified from the data object and time dimension, and the data Reports are managed in a template, and real-time dynamic adjustments are made according to the requirements of superiors to achieve rapid response to data resources. Further through the investigation of performance requirements, the performance requirements of the model are summarized, and performance indicators, capacity indicators, and data indicators are summarized etc., as shown in Table 1.

By establishing an energy efficiency monitoring model, real-time monitoring, flexible deployment, and unified management are realized. With the expansion of the monitoring scope and the increase of storage capacity, the energy efficiency monitoring model can be adjusted flexibly without major adjustments. The station operation status monitoring model is divided into five sub-models: information collection model, quality online monitoring model, efficiency benchmarking evaluation sub-model, efficiency benchmarking evaluation sub-model and efficiency benchmarking evaluation sub-model. Introduce the functions of each sub-model in turn. The function module structure is shown in Figure 5.

![Figure 5 model function module structure](image)

Before and after the implementation of the station operation status monitoring project, through the comparison of comprehensive data such as energy consumption, load, electricity, and power factor, the effect of station operation status monitoring can be grasped. And further optimize the function structure of the running state monitoring function sub-module, as shown in Figure 6:

![Figure 6 sub module function of running state monitoring function](image)

Further adopt 3D imaging technology, establish virtual simulation scenes and high-precision models, and quickly obtain on-site response methods. In order to ensure the rationality and safety of the implementation of the plan, it is necessary to provide data support for the plan feedback model. The program obtained from the monitoring is applied to the scene of the incident through the gas-related module, the data is processed and analyzed, and the processing results are fed back to the information center. Combine the high-precision model to compare and monitor the final design plan. By establishing a multi-layer energy consumption model, the safe and reasonable operation of natural
gas filling stations can be monitored according to the correlation between various parameters. And optimize the coupling detection process of station operation status, as shown in Figure 7:

![Diagram showing process optimization of coupling monitoring of station operation state]

In order to ensure the smooth implementation of the coupled monitoring project of the operation status of energy farms and stations, at least one energy management manager must be appointed. And be responsible for energy-related production activities. Create new positions and responsibilities that are conducive to the execution of energy management projects. Real-time monitoring of the index data of each station, the data items are shown in Table 2.

| Serial number | data item                  | Company          |
|---------------|----------------------------|------------------|
| 1             | Daily air intake           | m³               |
| 2             | temperature                | °C               |
| 3             | Inlet and outlet pressure  | M Pa             |
| 4             | Instantaneous flow         | m³/h             |
| 5             | Inlet and outlet pressure  | M Pa             |
| 6             | temperature                | °C               |
| 7             | Instantaneous flow         | m³/h             |
| 8             | Real time gas storage      | m³               |
| 9             | Conveying capacity         | m³               |
| 10            | pressure                   | M Pa             |
| 11            | temperature                | °C               |
| 12            | Instantaneous flow         | m³/h             |
| 13            | Cumulative flow            | m³               |

According to the definition of energy monitoring, energy monitoring mainly refers to the effective and reasonable allocation and monitoring of energy by energy users when using energy, so as to make it an efficient and clean process and minimize energy consumption. It is necessary for the establishment and effective operation of energy management system to accurately monitor the operation status of new energy stations.

3. Analysis of experimental results
In order to verify the application effect of the new energy field and station operating status coupling monitoring model based on data mining, experimental testing was carried out. In order to better simulate the effect of the formal environment, the software configuration information, middleware
deployment parameters and database deployment parameters in the test environment. The settings are the same as those in the actual environment, but in the hardware environment, the server configuration is a stand-alone machine, and the entire interface is mainly used to obtain user feedback information through communication with end users. The experimental parameters are shown in Table 3.

Table 3  experimental parameter setting

| Serial number | Test content | test result      |
|---------------|--------------|------------------|
| 1             | Interface testing | normal           |
| 2             | Data testing   | Same as test data|
| 3             | Overall test   | Complete function|

Further statistical monitoring of the recognition model takes a long time, and the statistical results are shown in Table 4.

Table 4  statistical table of station operation status monitoring data identification

| Image number | Traditional model | Intelligent monitoring model based recognition |
|--------------|-------------------|-----------------------------------------------|
| 1            | 1.253.52          | 0.998.52                                      |
| 2            | 1.093.52          | 0.865.31                                      |
| 3            | 1.137.14          | 1.023.21                                      |
| 4            | 1.126.32          | 1.000.91                                      |
| 5            | 1.457.89          | 0.878.56                                      |
| 6            | 1.236.91          | 0.893.24                                      |

Furthermore, the pixel-to-hour ratio is used as an indicator of recognition efficiency to conduct a comparative test of the status monitoring effect. The specific test results are shown in Figure 8.

The test results show that the monitoring method can effectively improve the efficiency of energy comprehensive utilization, solve the problem of low accuracy of previous monitoring methods, and has a good application prospect. With its good stability and monitoring effect, new energy monitoring is regarded as the main direction of new energy development in many areas.

![Figure 8](image_url)

**Figure 8 Comparison and analysis of operation condition monitoring results**

4. Conclusion

According to the development trend of monitoring and comprehensive analysis management technology of new energy station, this paper proposes to establish new energy data comprehensive analysis and management mode in new energy station dispatching control mode zone 1, so as to
improve new energy dispatching operation management means and meet the growing demand of daily operation analysis and data management.

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