Research on Energy Management System Based on Multi-Agent

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Abstract—Now energy consumption is much higher than before. The shortage of energy has become a prominent economic and social development constraint. Despite a great deal of research, a number of challenges still exist before making agent-based computing a widely accepted in energy management practice. This paper developed a new energy management system based on multi-agent which can provide modern energy management means for enterprises, ultimately achieve energy saving and improve energy utilization efficiency.

Index Terms—Energy Management, Management System, Multi-Agent

I. INTRODUCTION

Today, the world's population already exceeded 6.0 billion and energy consumption has increased more and more. According to current consumption, experts predict that oil and natural gas can only maintain less than half a century, coal can only be maintained a century. So, no matter what kind of conventional energy structure, the energy crisis the human facing is becoming increasingly serious. As the world's largest developing country, Chinese energy resources per capita is much lower than the average of world. However, due to technical and human factors, low efficiency of Chinese energy situation is very conspicuous. Chinese energy crisis are mainly showed in two aspects:

(1) Energy shortages, Chinese total energy cannot meet the socio-economic sustainable development and the daily needs of the masses;

(2) Energy utilization efficiency is low, mainly reflected in the high energy consumption and low efficiency.

Industry officials and scholars believe that China on the one hand must develop nuclear power, wind power and other new energy sources and renewable energy; on the other hand China must adjust the energy structure, and vigorously implement energy-saving to improve energy utilization efficiency [1].

To solve the energy crisis, China must be based on the adjustment of economic structure and improving energy structure, which also determines the long-term and difficult task of improving energy utilization efficiency [2]. Therefore, the current and future period, china should adjust the energy structure, and vigorously implement energy-saving to improve energy utilization efficiency [3].

In this paper, the authors developed a new energy management system based on multi-agent which can use modern means of management to achieve real-time monitoring of energy data and scientific deployment, and ultimately achieving energy saving and improve energy utilization efficiency.

II. ENERGY MANAGEMENT SYSTEM MODEL

Agent technology appeared in the 70s of the 20th century. Agent can be defined as: an entity has the capacity of calculating, perceiving, reasoning, operating and communicating [4]. Multi-agent system is composed of some Agents. Multi-agent technology can be applied to the research of energy management [5]. The combination of energy management and Multi-agent technology has the following features:

(1) Adaptability: Based on the information of energy, Agent can discover the characteristics of energy consumption, reason the optimistic needs and establish consumption plan;

(2) Initiative: Agent can initiatively find the corresponding information based on energy demands, and even can monitor the changes of energy sources;

(3) Collaborative: Agents can share the information with other Agents. For example, a user's Agent can access to a lot of useful information from other users' Agents [5].

In the energy management system, we should understand the entire production process as well as the type of energy, build pipeline network structure, collect and search energy consumption data and energy consumption indicators [6]. Second, to achieve dynamic real-time monitoring, the system should collect data about transmission loss, energy-consuming equipment status and the level of energy utilization efficiency; such as the power supply and distribution systems, power system, watercourse systems, environmental systems, etc.; thirdly, achieving management optimization, the system should analyze relevant dynamical data, use relevant models to achieve balance between energy supply and demand, optimize energy consumption [7].

So, the new energy management system is built up as energy monitoring and scheduling system based on multi-agent. The system is shown as follow:

The workflow of the new energy management system is designed as follow [8]:

(1) Storing the basic data about energy, power systems, process flow, equipment and other basic information in the database.
(2) Data Acquisition Agents collect real-time dynamic data, and store the basic data in the database.

(3) Data Processing Agent use data fusion techniques to process data stored in the database.

(4) According to data stored in the database, Energy Scheduling Agent and Device Control Agents produce the plan of energy scheduling optimization and device control optimization. The modules will manage energy in the processes of storage, transmission, processing and using, and control a variety of equipments.

5) Data Acquisition Agent continues to collect real-time dynamic data.

III. ARCHITECTURE OF ENERGY MANAGEMENT SYSTEM

A. Data Acquisition Agent

The Data Acquisition Agent includes Collect Robot, Collect Strategy and Collect Optimization.

1) In the production and operation process, the Collect Robot mainly collects dynamic real-time energy data, production processes data and equipment data. These data are very important to master the specific storage, process and using of energy in various power systems. Based on Collect Strategy and Collect Optimization, the robot will take different collection strategies to ensure gathering up relevant key parameters effectively and timely.

2) Collect Strategy includes breadth-first search strategy, depth-first strategy and address search strategy.

3) Collect Optimization will optimize collect strategy base on different power systems, production processes and equipments.

B. Data Processing Agent

Since the energy systems almost concerned all aspects of enterprise, so the amount of data collected up is very large, and most of the existing systems just make a simple concoction of these data, this will result in low efficiency of the follow-up analysis of results.

So, Data Processing Agent includes Data Extracting, Data Cleaning, Data Clustering and Data Transforming.

1) Data Extracting is responsible for search reasonable data. It will utilize some intelligent algorithms to search information stored in database.

2) Data Cleaning is an important component which identifies probable data. It will modify or delete some data. Meaningless data in the database will be removed. This component will also filter the data in different formats, eliminate the noise content, and integrate uniform data. It ultimately ensures consistency and integrity of data.

3) Data Clustering will use warehouse technology to classify data, so, this will improve information search and storage efficiency.

C. Energy Scheduling Agent

According to the real-time data collected by Data Acquisition Agent, Energy Scheduling Agent will use the basic data about energy, power systems, production processes and equipments to organize multi-dimensional data views.

Energy Scheduling Agent includes Knowledge Base, Module Base and Scheduling.

1) Knowledge base: It includes the information about equipments and energy. When scheduling, the agent will make use of these information to schedule and search more accurate and useful information for energy management.

2) Module Base includes relevant optimization models, such as: pipe network traffic and pressure homeostasis computing model, time series forecasting model, dynamic balance of the pre-calculation model, correlation analysis and principal component analysis of data mining models, to ensure energy achieving balance optimization and energy consumption optimization, such as: conducting a detailed load analysis and forecasting, energy quantity and quality control, all aspects of energy ratio and so on.
3) According to the Model Base, this component will choose appropriate models and algorithms to schedule detailed energy consumption, and in accordance with the result, the control signals will be submitted to the Device Control Agent.

![Diagram](image.png)  
**Figure 4. Energy Scheduling Agent.**

D. Device Control Agent

According to the real-time data collected by Data Acquisition Agent, and the dynamic interaction with Energy Scheduling Agent, and the energy optimization program, Device Control Agent will implement the remote operation of equipment, such as: start, stop, forward, anti-switch and set the prescriptive value for a given operation.

E. Information Dissemination Agent

Information Dissemination Agent is mainly responsible for releasing information including the different forms of energy statistical reports, for higher authorities, relevant government departments, industry peers and the public.

F. Database

It is mainly used to record the basic data about all aspects of business, such as the real-time dynamic collected by Data Acquisition Agent, scheduling optimization plans produced by Energy Scheduling Agent, decisions made by Equipment Control Module, results related to energy analysis and so on.

IV. Key Technology

The key technologies used in the system are shown as follows:

1) Energy Data Integration Technology: Energy system involves many aspects covering almost all production sectors, the data about time granularity and type varies widely from the second-level real-time data to the weeks, months, years of planning data and operational management data. So Data Integration had proved to be difficult.

2) Energy Dynamic Balance Analysis Technology: The balance analysis of the current energy system is mostly static. For the goal to minimize waste of energy, dynamic balance analysis of equilibrium achieving grade-minute is most needed.

3) Multi-scale Analysis Technology: due to incomplete data, and lack of effective technical means, most current systems is only in the level of simple statistics and daily reports, in-depth extraction of information and operation optimization have not yet reached.

4) Energy Process Control Technology: the key equipments and key processes of energy consumption are accounted for the majority of the total energy consumption. If these key equipments and processes can be running at its best, then the enterprises will be able to greatly improve the situation of energy consumption.

V. Conclusion

Saving energy is urgently needed in Chinese economic development. Although many enterprises have understood the importance of energy saving. But, the enterprises lack a systematic management of energy consumption. Energy management using information technology can greatly improve the efficiency of enterprise management and utilization of energy, reduce energy costs, and enhance the competitiveness of enterprises. In short, Energy Management System can play an important role in realizing energy optimization.

In this paper, the authors put forward a new energy management system based on multi-agent; it includes Data Acquisition Agent, Data Processing Agent, Energy Scheduling Agent, Device Control Agent, Information Dissemination Agent and Database. It can achieve the integration of multi-agent and energy management.

REFERENCES


