Application Research of Customer Side Integrated Energy Service System Based on Machine Learning

Yizhao Luo*, Chao Zhan, YuLuan Liu, Huang Yu, Ronggui Li
Fujian Netpower Technology Development Co., Ltd., Fujian Fuzhou,350003

*Corresponding author: luo_yizhao2020@foxmail.com

Abstract. With the emergence of Internet, big data, cloud computing, block chain technology and other high-tech technologies, the integrated energy service mode including more clean energy and micro grid technology has quietly begun. This paper defines the connotation and value of integrated energy services, and constructs the theoretical framework of comprehensive energy services evaluation system based on the traditional balanced scorecard. This paper analyzes the current situation of domestic and foreign energy markets and the scope of comprehensive services. Finally, the difficulties and challenges faced by the energy integrated service industry are analyzed, and the after tax internal rate of return is 11.2%, which provides a reference for the transformation of energy enterprises.

1. Introduction

With the continuous progress of science and technology, machine learning technology has become an indispensable part of our life. Machine learning is one of the fastest developing technology fields in the interdisciplinary of computer science and statistics, and is the core of artificial intelligence and data science.

Due to the continuous progress of information technology, many experts have studied machine learning technology. For example, a team in China has studied the application of machine learning algorithm in data mining technology, and found two problems: using a large number of road test mobile terminals to receive level signal data, positioning outdoor mobile terminals in the network, and using a large number of user data to predict user contact in social networks. Support vector machine optimization algorithm is used to train the feature set of user data. At the same time, the link in social network application is predicted, and the prediction accuracy and speed are high. First order polynomial kernel function and mesh optimization method are used to configure penalty factor and kernel function parameters. In the training stage, the feature vector formed by the signal level received by the mobile terminal is substituted into a set of decision functions. By calculating the similarity or distance measurement between the level measurement report received from the mobile terminal and the level measurement report of the received training data set in the partition grid [1]. Some experts have studied the online machine learning algorithm under big data, and introduced the basic concept of power quality disturbance classification, the generated power quality disturbance data set and the detailed process of feature extraction. This paper analyzes Hadoop, spark and other commonly used big data tools, describes their architecture and principle in detail, studies the transformation of online machine learning algorithm in big data environment, discusses the data segmentation based on sample dimension and data
segmentation based on feature dimension, introduces the process of generating power quality disturbance data set and feature extraction, and builds a set of big data experimental environment. Describes the specific steps of virtual machine establishment and system installation, gives the installation and remote management of big data environment in the process of running environment construction, and gives the core algorithm of running program and the logical implementation of the system. The theoretical analysis is carried out from two aspects of online transformation of traditional machine learning algorithm and online machine learning algorithm transformation in big data environment, and the application effect of online machine learning algorithm in power quality disturbance classification is analyzed [2]. Some experts have studied the design of green building intelligent control system based on machine learning, analyzed the main factors affecting the setting of satisfactory environmental parameters, optimized the key parameters of the prediction model by using improved adaptive particle swarm optimization algorithm and improved adaptive genetic algorithm, and analyzed the research status of green building intelligent control system based on machine learning at home and abroad. Using the temporal reasoning model based on habit, the wireless location engine is developed independently. At the same time, the influencing variables of environmental parameters of customer satisfaction are analyzed. Finally, the mathematical prediction model of environmental parameters of customer satisfaction is established. Although the research results of machine learning algorithm are quite fruitful, there are still some deficiencies in the application of machine learning client integrated energy service system.

In this paper, in order to study the customer side integrated energy service system of machine learning, through the research of customer side integration and energy service, we found the target of relative value of energy consumption and carbon emission of community buildings. The results show that machine learning is conducive to the application of customer side integrated energy service system.

2. Method

2.1. Customer Side Integrated and Energy Services
The customer side integrated energy service is the most basic service based on the optimal utilization of comprehensive energy. Customer side integrated energy service is a multi-user integrated service system based on energy application. Through the Internet open platform, it can realize the monitoring, operation and energy efficiency management of energy supply and energy consumption system. As a comprehensive energy service provider, the customer side integrated energy service can set up an independent energy-saving service company according to the needs of users to provide energy-saving service transformation scheme for users [4]. Share the benefits of energy conservation and emission reduction; actively participate in carbon emission trading according to the carbon emission reduction achievements of enterprises and the demand of carbon trading market, and provide carbon emission quota service for other enterprises that have not completed the carbon emission task. The customer side integrated energy service planning system is divided into three levels: the first level of energy infrastructure, the construction of primary energy physical facilities, the second level of information perception, information awareness, communication network construction, data access and interconnection of information facilities, and the third level of value creation and application rely on the new resources formed after the integration of CPS, so as to achieve the goal of urban energy transformation planning[ 5]. The quasi steady state model of integrated energy services on the user side is the basis of coordinated dispatching of integrated energy systems. It pays more attention to the value-added services brought by information flow and business flow. This change will also subvert the market environment, business model, industrial structure, technical system and management system of the traditional energy industry. The quasi steady state mode of the integrated energy system is the basis for coordinated dispatching of the integrated energy system [6]. In the research of integrated energy system, multi-energy coordination and complement among different energy systems is the key to improve the comprehensive utilization rate of energy and save energy cost of users. However, in most of the integrated energy systems, cold, heat, electricity and gas are separated from each other, resulting in low
energy efficiency. The comprehensive energy services on the customer side will support the extensive access of high proportion of distributed energy on the demand side, further improve energy efficiency and realize energy conservation and emission reduction through local absorption and interconnection. In the process of paying attention to energy flow, we should promote green energy and efficient utilization of energy, and promote the open interconnection and democratization of energy system. In short, the energy Internet will be a disruptive technology, which will lead to significant changes in the energy field [7].

2.2. Target Reflecting Relative Values of Energy Consumption and Carbon Emission of Community Buildings

Building energy saving rate and carbon emission reduction rate of building energy consumption. According to China's 64%, 31% and 32% building energy-saving strategies, the specific goal of building energy-saving in community planning can be formulated according to the national energy-saving standard of 75%. However, it should be pointed out that when formulating the energy saving rate, it is necessary to define the baseline scenario and fully consider the application of local climate conditions, resource endowment and technology. The carbon emission reduction rate of building energy consumption is defined as:

\[
GSA = \frac{100*HFD}{DA + GF + FD}
\]  

Where: GSA is the efficiency of carbon emission reduction; HFD is to avoid carbon emission, that is, due to the improvement of energy efficiency of energy consuming equipment, the carbon emission is reduced compared with the original, and the resulting carbon emission is to avoid carbon emission; Da is the implied carbon emission, that is, there is no carbon emission during the use of energy consuming equipment, but there is carbon emission in the production, manufacturing, transportation and installation process of its life cycle, which is hidden Carbon emission; GF is indirect carbon emission, which refers to indirect carbon emission generated by thermal power generation by energy consuming equipment using electricity and carbon energy; FD refers to direct carbon emission, which refers to carbon emission generated by energy consumption equipment directly driven by urban energy coal, natural gas and oil [8].

3. Experience

3.1. Extraction of Experimental Objects

According to the basic situation of existing buildings, the building model is established by software, and the dynamic load simulation calculation is carried out after the relevant parameters are set [9]. By simulating different types of typical building energy consumption, the sample database is established. Buildings with similar building characteristics and operating modes are classified as a type of building with similar hourly and seasonal load curves in terms of energy consumption. The goal of the model is to minimize the daily operation cost of the whole life cycle cost of the equipment, including power purchase cost, fuel cost, equipment operation and maintenance cost, equipment depreciation cost and equipment start-up and shutdown cost. The integration mode of energy conservation, emission reduction and service is a comprehensive mode in which enterprises provide energy-saving services for users on the basis of the integration mode of energy-saving emission reduction and service.

3.2. Analysis of Experimental Objects

On the premise of meeting the access constraints, the environmental protection benefits are converted into economic benefits for calculation. The combination of environmental protection benefits and economic benefits is more operable, which reflects the characteristics of energy utilization efficiency to a certain extent. The work framework of regional energy planning is mainly divided into three steps to
complete the goal planning [10]. In the first step, based on the policies, standards and cases, combined with the actual situation of the project area and the superior planning, the preliminary analysis of resource conditions, infrastructure, energy demand, etc. is carried out to clarify the planning objectives and key points; the second step is to select the appropriate energy supply system and mode, determine the reasonable service scope and construct the energy system planning scheme through the comprehensive balance analysis of energy supply and demand. In the third step, the index system and implementation scheme are put forward, the regional energy system control index system is proposed, and the investment and financing operation mode and phased implementation scheme are defined. When the state of visible layer is known, the activation probability of eth cell in hidden layer h is calculated as follows:

$$P(h_j = 1 | v) = \text{sigm}(\sum_{i=1}^{n} w_{ij} v_i + a_j)$$ \hspace{0.5cm} (2)

$$P(v_i=1 | h) = \text{sigm}(\sum_{j=1}^{M} w_{ij} h_j + b_i)$$ \hspace{0.5cm} (3)

According to the building types in the plot, the matching model samples are selected from the sample library as follows:

$$P_{hit} = \sum_{j=1}^{N} A_j \sum_{i=1}^{M} P_j I_{ij}$$ \hspace{0.5cm} (4)

Where: $A_j$ is the total area of the building I in the plot; $P_j$ is the prediction parameter of the building area of class J typical building unit; is the attribute unit matrix; if building I belongs to class J, $I_{ij} = 1$ otherwise $I_{ij} = 0$; n is the total number of buildings and M is the total number of typical building types.

4. Discussion

4.1. Calculation Results of Economic Feasibility

The benefits of comprehensive energy service providers in distribution, power sales, refrigeration, heating, demand side and other aspects are given to users to a certain extent, which can save energy costs for users. Through the energy Internet management platform and intelligent terminal, the demand side management of the user side is carried out, and the exclusive energy consumption scheme is formulated for the user, and the energy consumption behavior of the user is reasonably guided, and the energy consumption cost of peak shaving and valley filling is saved for users. In case of emergency, a large area of power outage will be arranged to support the key loads in the park. The parameter values are substituted into the economic feasibility model to analyze the economic feasibility of the park energy Internet application in the comprehensive energy service mode. The income statement and cash flow statement after calculation are shown in Table 1.
**Table 1. Income statement**

| particular year | Economic benefits | Financial cost | depreciation | Total profit | income tax | Net profit |
|-----------------|-------------------|----------------|--------------|--------------|------------|------------|
| 2015            | 9876              | 1656           | 1689         | 1870         | 4351       | 3124       |
| 2016            | 7865              | 2865           | 2675         | 4465         | 7666       | 4356       |
| 2017            | 9098              | 2868           | 2876         | 2566         | 3676       | 5344       |
| 2018            | 8721              | 3786           | 3789         | 4541         | 6434       | 3456       |
| 2019            | 9868              | 4776           | 4787         | 4534         | 2645       | 6786       |

It can be seen from the above figure that under the integrated energy service mode, the total investment of the project can be recovered in about 8.6 years. The after tax internal rate of return is 11.2%, higher than the benchmark rate of return, and the net present value is positive. The economic benefits are at a reasonable level.

The benefits of comprehensive energy service providers in distribution, power sales, refrigeration, heating, demand side and other aspects are given to users to a certain extent, which can save energy costs for users. In the first year, 4.35 million yuan of energy consumption can be saved. The specific cost saving effect is shown in Figure 1.

![Figure 1. Energy saving cost of users in the first year](image)

It can be seen from the above that comprehensive energy service providers give users a certain degree of concession in terms of power distribution, power sales, cooling, heating and demand side, so that users can save 1323.5 yuan in power consumption, 678.6 yuan in heat consumption, and 974.9 yuan in cooling.

### 4.2 Economic Indicators of Energy Market

Oil and gas exploitation is a field that relies on technological progress to increase resource utilization efficiency and improve market supply capacity. With the gradual depletion of easily recoverable resources, it is necessary to rely on technological progress to improve the discovery and utilization efficiency of unknown and complex resources, so as to ensure the continuity of resource supply before the emergence of new alternative energy varieties. As shown in Table 2.
Table 2. Economic indicators of major manufacturers in China's oil and gas market

|                | FSD       | DGS       | DSF       | GJK       |
|----------------|-----------|-----------|-----------|-----------|
| gas station    | 2765Seat  | 1364Seat  | 998Seat   | 1757Seat  |
| Natural gas management | 0         | 352KM     | 453KM     | 675KM     |
| Sales volume of refined oil | 5432ton   | 3122ton   | 634ton    | 945ton    |
| Sales volume of natural gas | 132.4million cubic meters | 32.4million cubic meters | 63.6million cubic meters | 68.9million cubic meters |
| business income | 13522RMB  | 4132RMB   | 6732RMB   | 2343RMB   |

From the data in Table 2, it can be seen that in 2018, only the five major power generation groups accounted for 45.64% of the installed capacity of the national generation side market, and the power generation accounted for 53.54% of the national electricity consumption.

4.3. Results Display Data
Select a domain scenario, click the energy demand calculation button, and take the operation unit scenario as an example to get the electricity load supply of 24 hours per hour. At the same time, the energy change curve is given, as shown in Figure 2.

![Figure 2. Demand curve of hourly electric load of the day](image)

It can be seen from the above that the power generation efficiency of co generation is 12% - 32%, the thermal efficiency is 23% - 54%, and the energy conversion efficiency of other equipment is above 87%.

5. Conclusion
With the promotion of a new round of system reform, various comprehensive energy services emerge in endlessly in China, and regional energy market competition is also changing rapidly. It is an important
goal of energy development in China to promote the coordinated development of comprehensive energy and realize the complement of various energy sources. Integrated energy services are the key means to achieve this goal. A gas electricity dynamic coupling model considering the comprehensive energy planning of wind power, wind turbine and co-generation unit is established. The flexibility of integrated energy system and the energy conversion capacity between power system and natural gas system are necessary conditions for large-scale wind power consumption. Due to the intermediary, volatility and randomness of wind power, a comprehensive energy system expansion planning model considering the coupling of power system, gas system and thermal system is proposed. Based on the relationship curve between load duration and wind intensity, scenario method is used to explain the uncertainty of wind power and load, which can significantly reduce construction and operation costs, provide customized energy services for users and improve energy utilization efficiency.

Reference

[1] Dincer I, Bicer Y . Enhanced dimensions of integrated energy systems for environment and sustainability[J]. Energy, 2020:93-99.
[2] Chang S, Ge S, Yining G et al. Smart Grid Data Security Aggregation Method Based on Fog Computing Architecture for Integrated Energy Services[J]. IOP Conference Series Earth and Environmental ence, 2020, 512:012116.
[3] Lazarevic D, Kivimaa P, Lukkarinen J et al. Understanding integrated-solution innovations in sustainability transitions: Reconfigurative building-energy services in Finland[J]. Energy Research & Social ence, 2019, 56:101209.
[4] Han W, Ang L E. ON Group: Clean Energy Leads Integrated Energy Services[J]. IOP Conference Series: Materials ence and Engineering, 2018, 439(5):052039 (6pp).
[5] Xu X, Li K, Yu X, et al. Implications of Gas Infrastructure in Integrated Community Energy Systems[J]. Journal of Energy Engineering, 2017, 143(5):04017053.1-04017053.9.
[6] Dalla Longa F, Strikkers T, Kober T, et al. Advancing Energy Access Modelling with Geographic Information System Data[J]. Environmental Modeling & Assessment, 2018, 23(6):627-637.
[7] Boroumand R H, Goutte S, Guesmi K, et al. Potential benefits of optimal intra-day electricity hedging for the environment: The perspective of electricity retailers[J]. Energy Policy, 2019, 132(SEP.):1120-1129.
[8] Ching-Hu L. IoT-Enabled Adaptive Context-Aware and Playful Cyber-Physical System for Everyday Energy Savings[J]. IEEE Transactions on Human-Machine Systems, 2018, 48:380-391.
[9] Madrazo L, Álvaro Sicilia, Massetti M, et al. Enhancing energy performance certificates with energy related data to support decision making for building retrofitting[J]. Thermal ence, 2018, 22:28-28.
[10] Panda S K. Geospatial Framework of Urban Waste to Energy: A case study of Amaravati Capital City[J]. International Journal of Pure and Applied Mathematics, 2017, 117(18).
[11] Repo S, Ponci F, Giustina D D, et al. The IDE4L Project: Defining, Designing, and Demonstrating the Ideal Grid for All[J]. IEEE Power and Energy Magazine, 2017, 15(3):41-51.