ICJK
Journal of Numerical Simulations in Physics and Mathematics
http://dx.doi.org/10.62762/JNSPM.2025.109244

RESEARCH ARTICLE

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Optimal Control Method of Temperature-Controlled Load Energy-Saving Technology for Industrial and Commercial Users Integrating Multi-Modal Target Detection, Identification and Tracking Models

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Abstract

This paper proposed an intelligent temperature-controlled load energy-saving technology based on multi-modal target detection, recognition and tracking, aiming to study the integration of traditional power energy-saving technology and high-tech multi-modal target detection, recognition and tracking technology. The method proposed in this paper was to use the energy management model of temperature-controlled load based on multi-modal target detection, identification and tracking and aggregate response algorithm to carry out energy-saving management of user's temperature-controlled load. The two algorithms jointly carried out energy-saving and optimal management of electrical appliances. Through the analysis of the electrical load optimization management experiment, after the energy saving optimization of the air conditioner, its 24-hour total power has dropped by 61kW, and the temperature has dropped by 3 degrees Celsius. After the energy saving optimization of the electric water heater, its 24-hour total power has dropped by 37kW and the temperature has dropped by 5 degrees Celsius. This shows that the power load (PL) temperature control and energy-saving technology can effectively save energy and control the temperature of electrical appliances. The experimental results can effectively demonstrate that the research on the optimal control method of the temperature-controlled load energy-saving technology based on multi-modal target detection, identification and tracking is feasible. The results of this study clearly show that the multi-modal target detection, recognition and tracking technology can be well applied to the current PL temperature control and energy saving, which provides a possible development direction for the future PL energy saving processing technology.

Submitted: 02 June 2025
Accepted: 22 June 2025
Published: 29 June 2025

Vol. 1, **No.** 1, 2025.
10.62762/JNSPM.2025.109244

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Citation
Li, Y., Sun, Y., Ma L., Zhao, Z., & Shan, C. (2025). Optimal Control Method of Temperature-Controlled Load Energy-Saving Technology for Industrial and Commercial Users Integrating Multi-Modal Target Detection, Identification and Tracking Models. *Journal of Numerical Simulations in Physics and Mathematics*, 1(1), 7–17.

Keywords: multi-modal Ttarget detection, industrial and commercial users, temperature control load energy saving, power supply industry, aggregate response algorithm.

1 Introduction

In recent years, the world's electricity demand has gradually increased, and the power gap has become more and more prominent. The contradiction between power supply and demand continues to deepen. Therefore, high-efficiency power-saving technology has become an urgent need. Generally speaking, the temperature-controlled load energy-saving technology can optimize the use of electricity by using high-tech technologies and equipment such as cloud computing and deep learning, so as to use electricity more efficiently and save electricity resources to the greatest extent. The temperature-controlled load energy-saving technology not only reduces the power loss, but also plays a vital role in promoting the upgrade of the entire power energy protection, and also opens up a path for the power energy protection industry. China has made a lot of achievements in the research of temperature-controlled load energy-saving technology that can effectively face the current power energy saving problem. However, with the rapid development of industry and commerce, in the face of the current complex electricity environment, many problems have naturally appeared in the past traditional power saving technologies. Therefore, it is urgent to combine the current high-tech multi-modal target detection, recognition and tracking technology with the traditional temperature-controlled load energy-saving technology to seek a new way of power saving. At present, the research on temperature-controlled load energy-saving technology under the background of multi-modal target detection, recognition and tracking is still in its infancy. Since entering modern society, network technology has developed rapidly. Many scholars have carried out scientific research on temperature control load energy saving technology. Ni P pointed out that continuous motion heating and cooling systems were common in many office buildings. Excessive heating and cooling creates wasted energy. Smart energy-saving devices could effectively save energy. He chose a parametric performance simulation tool to simulate the energy consumption of an office building in a typical climate zone. The methods he used were intelligent control and the effect of continuous operation on heating and cooling energy loads at different window-to-wall ratios, respectively. Considering the energy consumption of additional equipment of intelligent control, the energy saving rate of intelligent control and continuous operation control were compared. The results showed that intelligent control was more energy efficient than continuous operation in heating and cooling modes in different climate zones and different window-to-wall ratios. The study further showed that intelligent control systems could help improve building energy efficiency and open up new avenues for energy exploitation [1]. Wang C conducted research on Optical-Variable Walls (OVW) and found that they could adjust the reflectivity of solar radiation. By absorbing and storing solar radiation in summer and releasing heat in winter, a building's energy consumption could be significantly reduced. He investigated the ability of optically variable walls to control temperature. He described the effect of OVW on indoor air temperature. In summary, OVW could reduce heating and cooling loads and control indoor temperature well. The thermal load was close to OFW (Optical-Fixed Wall) and the reflectivity was low. OVW cooling loads had a similar effect as using a highly reflective OFW. In terms of temperature regulation, narrow temperature zones could help reduce HVAC loads. The results of this study provided new options for the energy-saving design of green buildings and provided directions for the future development and performance improvement of OVW [2]. Research by Bouazza K E pointed to a steady increase in energy consumption, which was putting constant pressure on electrical loads. The implement of energy conservation and emission reduction policies was the current top priority. He developed an energy saving model that incorporated new advanced technologies into conventional air conditioning (AC) for optimal operating energy efficiency. In his research, he designed a third-order intelligent control framework that allowed users to control the room temperature at any time. Sensors and actuation devices were interconnected to speed up temperature control efficiency. Real-time temperature detection and rapid response control could provide users with a comfortable and energy-saving environment. This experiment demonstrated the feasibility of the method. This study showed that both system responsiveness and user comfort must be taken into account while ensuring reduced energy consumption [3]. Song J studied the green building development strategy of urban public buildings, and implemented the energy-saving renovation plan of the project from the direction of green energy saving. He believed that building energy-saving renovation could effectively reduce energy consumption in the construction process, and project management could also improve the energy-saving effect of buildings. In the construction process, engineers need to maximize the use of various resources to achieve energy-saving requirements. In addition, energy-saving projects could help companies achieve better economic benefits and could play a sustainable role in the construction industry. Therefore, the realization of energy saving in public buildings is a complex task. The energy-saving design of doors, windows and roofs and how to correctly control room temperature were investigated from three perspectives: energy-saving design of indoor auxiliary equipment, wall insulation technology, and indoor energy-saving design [4].

The above achievements have studied the energy-saving technology of temperature-controlled load from various aspects, which is of great help to the research on the field of energy-saving of temperature-controlled load. However, their research does not link the temperature-controlled load energy saving technology with the multi-modal target detection, recognition and tracking technology, which is not conducive to further study research.

Today's technology is developing rapidly, the use of multi-modal target detection, identification and tracking algorithms to research temperature-controlled load energy-saving technology is a very novel proposal. Many scholars have conducted deeper research on multi-modal target detection, recognition and tracking technology. Toyabur R M designed a multi-mode hybrid electromagnetic energy harvester. The machine had multiple degrees of freedom mechanical vibration modes. This multi-mode hybrid energy harvester was specially designed to promote multiple closely resonant vibrational modes at different frequencies. A low spring rate material was used as a substrate, which could reduce the high resonant frequency of the harvester to a lower frequency range. It utilized two coupled conversion mechanisms to obtain higher output power with low input acceleration under ambient vibration. The simulation model could predict and optimize the MHEH vessel, allowing different mode shapes to be simulated. This vessel model could operate in the 12 to 22 Hz range. Under the same conditions, the maximum power generated by a single electromagnetic generator at 10Ω was $244.17\ \mu W$, indicating that the optimal load could be provided [5]. Hu used TRNSYS to build a heating system simulation model. The fuzzy controller model of solar heating system was established by MATLAB, and the two models were coupled to form a multi-modal tracking simulation model. The temperature changes and energy consumption inside the space in different environments were jointly simulated under the same environmental conditions. Most of the traditional solar source heat pump heating systems were controlled by a temperature difference controller, which consumed a lot of energy. In order to improve energy consumption, he considered the complexity of the heating system and used fuzzy strategies to improve the original system. Experiments showed that the solar collector was sensitive to light, and the temperature of the hot water tank was controlled between 57°C and 64°C. The use of traditional differential temperature controllers resulted in reduced system performance, increased energy consumption, and reduced economic efficiency. By using the fuzzy controller, the system performance could be improved by 6.2% and the energy consumption could be reduced by 22.82%. The daily economic benefit of the system could save 8.71 yuan [6]. Although the research of the above experts is comprehensive, it is only superficial, and no more in-depth research has been carried out. Most of their research principles are content, but the actual research still lacks certain practicality and reliability.

At present, the traditional temperature-controlled load energy-saving technology has many problems, such as low industrial power consumption efficiency, serious power waste, and insufficient power supply for residential power consumption peaks. In today's rapid development, the temperature-controlled load energy-saving technology also needs to be in line with the latest cutting-edge technology. Compared with the traditional temperature-controlled load energy-saving technology, the multi-modal target detection, identification and tracking technology is combined with the traditional temperature-controlled load energy-saving technology. It can solve many problems existing in the past, and can more efficiently implement temperature control load energy saving. The temperature can be controlled to the greatest extent on the premise of maintaining sufficient power efficiency.

2 Background and Significance

2.1 Concept of temperature control load

Temperature control load (TCL) is one of the most widely used flexible loads. It accounts for a large proportion of electricity consumption, and the proportion of peak load increases year by year [7, 8]. According to statistics, China's temperature control load accounts for about one-third of the peak summer electricity consumption in large cities. Most temperature-controlled loads today control room temperature through a simple switch control strategy. The switch control scheme is a relatively simple direct load control scheme, which can quickly and directly reduce the load power of the entire system. However, as the electricity industry evolves and reforms, users are no longer satisfied with simply participating directly in demand response. Future demand response models increasingly need to take into account the diverse power demands of users.

Coordinating temperature-controlled loads in a reasonable way and fully and efficiently exploiting its unique flexibility potential is the current research focus [9, 10]. So far, the research on temperature control load flexibility can be divided into two directions: research on comprehensive model of temperature control load and research on temperature control load control strategy. In the in-depth research, the research on temperature control load control strategy is roughly divided into: direct control temperature control load strategy and price demand temperature control load strategy. The control strategy for temperature control load is shown in Figure 1.

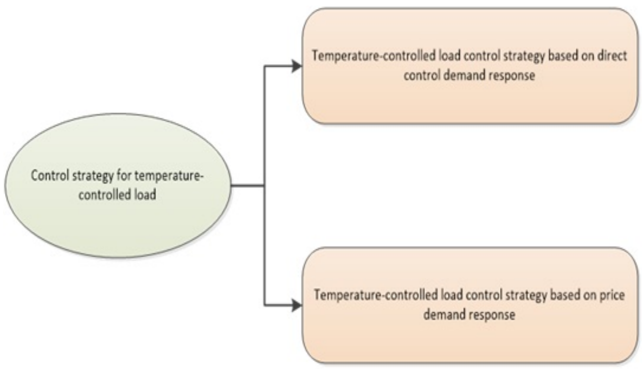

Figure 1. Control strategy diagram of temperature-controlled load.

This paper takes the related technologies and specific application requirements of temperature control loads as the starting point and destination. Guided by the improvement of the algorithm in the energy-saving efficiency of PL temperature control, a new power temperature control load control strategy is found.

2.2 Idea and characteristics of active PL

With the improvement of the automatic control ability of power installations and the development of smart home and intelligent interactive energy management systems, these changes have produced active loads [11, 12]. In intelligent PL control, other related demand response mechanisms should change the operating time and load size of the corresponding equipment to achieve solutions for power saving needs and energy control needs, and pursue higher power and energy economic benefits. The demand response based on active load has the following requirements. The premise of changing the size of the electricity load and the transfer of electricity time is that the user's energy usage habits or usage satisfaction rarely change. Load balancing can be coordinated with distributed energy sources such as solar energy. It has a certain power supply capability and can provide certain energy to other systems under certain conditions. Distributed power losses for active PLs are shown in Figure 2.

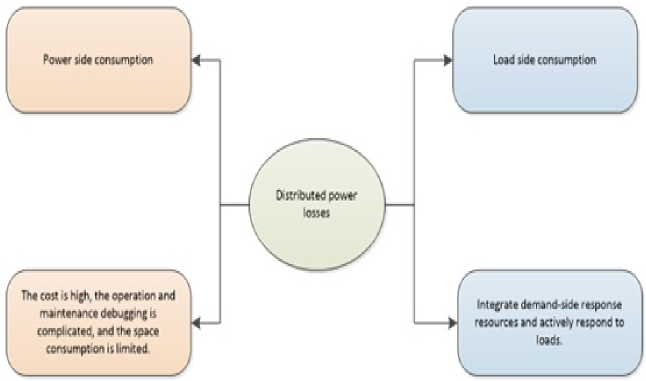

Figure 2. Distributed power loss diagram for active PLs.

From the above characteristics, it can be known that active load is the focus of customer demand side participation in demand response. In addition, with the large-scale popularization of distributed power sources such as rooftop solar power generation, the problem of distributed power consumption and energy saving in microgrids has gradually become prominent. Distributed power losses can be divided into two categories: power-side consumption and load-side consumption [13, 14]. For the power supply side, the consumption mode of the power supply side is used, which is costly, complicated in operation, maintenance and debugging, and consumes limited space. If the load-side power consumption method is used, the demand-side response resources can be integrated to actively respond to the load, thereby adjusting the operating cycle and power of each electrical equipment. It ensures the state of residents' electricity consumption to the greatest extent, thereby enhancing the anti-interference of residents' electricity consumption and improving the efficiency of residents' electricity consumption.

2.3 Influencing factors of PL

According to relevant researches, the factors affecting the change of PL are diverse, extensive and interrelated [15, 16]. Relevant factors include changes in time and climate, different weather and temperature, economic and financial fluctuations, international political conditions and changes in population, as well as environmental constraints and other special factors. Since the research object of this paper is the energy saving of temperature control loads of industrial and commercial users, it is less related to several macro factors such as economy, politics, and population. Time and weather factors have a major impact on small power consuming units. Therefore, this paper mainly focuses on the influence of these two factors on PL changes. The influence of time and weather factors on the PL is shown in Figure 3.

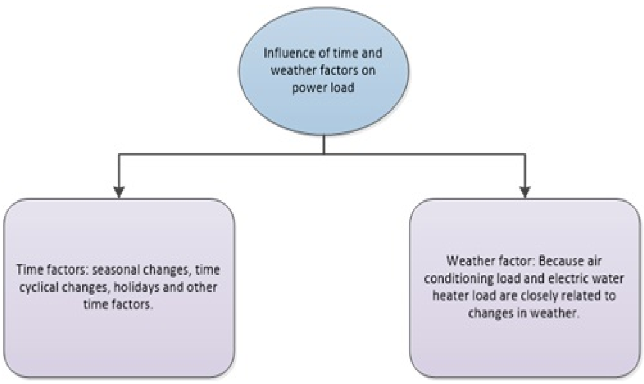

Figure 3. The influence of time and weather factors on PL.

Time factor: Seasonal changes, time cyclical changes, holidays and other time factors have a greater impact on the PL system. Therefore, the load curve exhibits different characteristics in different time ranges [17].

Weather factors: Air conditioning load and electric water heater load are closely related to changes in weather. Therefore, the weather factor is the key reason that affects the PL system. The influence of weather factors on PL is mostly reflected in the sudden change of PL [18].

3 Algorithms of Multi-Modal Target Detection, Recognition and Tracking Technology

3.1 Multi-modal fusion theory

The field of multi-modal fusion has developed rapidly, and its application fields are also very popular. The structures of its application scenarios mainly include: distributed fusion structure, centralized fusion structure and hybrid fusion structure [19, 20].

Distributed fusion structure: When data transmission enters the distributed fusion center, the fusion processor first collects and integrates the data. The distributed fusion architecture then uses processors to locally process the raw data collected by each sensor. At this time, the data retrieved by the fusion center is processed locally, which reduces the requirements for data center communication bandwidth and its own computing power during data transmission.

Centralized fusion structure: Different from the distributed fusion structure, the sensors in the centralized architecture mostly do the work of collecting target data. After aggregating the data, the raw or preprocessed data is transmitted to the fusion center. The fusion center checks the integrity and accuracy of the received data. However, at the same time, the communication bandwidth and its own computing power have high requirements in the process of data transmission. Centralized fusion structures are rarely used in practical applications because they cannot satisfy real-time performance.

Hybrid fusion structure: For hybrid fusion architectures, it combines the properties of distributed and centralized fusion architectures. Some sensors in the hybrid fusion architecture have corresponding processors, while others do not. At the meanwhile, the data acquired by the fusion center includes raw data and local data processed locally. Therefore, the communication bandwidth and computing power requirements of the hybrid fusion structure are in the middle of the other two fusion structures. Correspondingly, the hybrid fusion structure can satisfy certain measurement data integrity. However, raw data and local data need to be processed at the same time, which increases the difficulty of data processing algorithms in the fusion architecture.

3.2 Energy management model based on multi-modal temperature-controlled load

The energy management of temperature-controlled loads based on multi-modality needs to comprehensively consider the cost of electricity and the experience of electricity consumption, so as to balance the power consumption and temperature of electrical appliances to the greatest extent.

Objective function: First of all, it is necessary to reduce the sum of electricity cost and inappropriateness of electrical temperature control load, as shown in the following formula (1).

$$\min f = C_a + wU_a, \tag{1}$$

where U_a is user inappropriate and C_a is the electricity cost when the user's electrical appliance is running, which can be calculated using the following formula (2):

$$C_a = \sum_{t \in T} \lambda_n^t P_a^t \Delta t, \tag{2}$$

where λ_n^t and P_a^t are the electricity price and power consumption of the time period t, respectively, Δt is the period length, and λ_n^t is the electricity price of node n in period t.

It should be noted that the user's electricity consumption elasticity is obtained by comprehensively considering the user's electricity consumption cost and electricity consumption experience, as well as the characteristics of the user's electricity consumption behavior with the change of electricity price. The value of the weight W directly affects the flexibility of the user's electricity consumption. When w is 0, the user pays more attention to the power consumption cost. When w tends to infinity, users pay more attention to their power consumption experience. The less the power consumption behavior is affected by the price of electricity, the less elastic power consumption is. It should be noted that it is not straightforward to use a concrete method to determine the appropriate weight w, since w is related to each user's personal likes. Obviously, the weight of users who care about electricity comfort is more important than the weight of users who care about electricity bills. Each user can find the weight value w that suits them through a lot of experiments.

The negative experience is used to calculate the user's power consumption experience under temperature-controlled loads, that is, a quadratic convex function is established. It quantifies and normalizes the user's discomfort when exercising with a temperature-controlled load. The inappropriate function is as follows:

$$U_a = \frac{1}{D_{a,\max}} \sum_{t \in T_a} \left(T_{a,\text{in}}^t - T_{a,\text{in.best}} \right)^2, \tag{3}$$

$$D_{a,\max} = \left(T_{a,\text{in.max}} - T_{a,\text{in.min}} \right)^2 |T_a|, \tag{4}$$

where $|T_a|$ is the T_a-norm of a series of operating cycles, representing the length of time the load is operating. Formula (3) represents the normalized disturbance, and Formula (4) represents the temperature deviation increase. Among them, $T_{a,\text{in.best}}$, $T_{a,\text{in.max}}$, and $T_{a,\text{in.min}}$ are the most comfortable temperature in the user's room, the upper limit of acceptable room temperature, and the lower limit of acceptable room temperature, respectively. $T_{a,\text{in}}^t$ is room temperature. Obviously, the larger the temperature difference, the more uncomfortable the user feels. The discomfort is getting worse and worse. The value range of U_a is $[0, 1]$.

Constraints: There are some differences between commercial and domestic electricity usage environments, so they are modeled differently. The following formula (5) gives the thermodynamic model of the user temperature control load.

$$T'_{a,\text{in}} = \frac{Z'_a}{W_a}\left(1 - e^{-\frac{W_a}{Y_a}\Delta t}\right) + \frac{P'_a}{W_a}\left(1 - e^{-\frac{W_a}{Y_a}\Delta t}\right) - T'^{-1}_{a,\text{in}} e^{-\frac{W_a}{Y_a}\Delta t}, \tag{5}$$

where W_a is the heat transfer of the building outer layer of the commercial building, Y_a is the heat storage of the inner wall of the commercial building, the calculation of Z_a is related to the outdoor temperature and the external wall cooling load temperature in the period t.

The thermodynamic model of temperature control load for residential users is shown in the following formula (6).

$$T_{u,\text{in}}^t = T_{a,\text{out}}^t\left(1 - e^{-\frac{\Delta t}{R_a C_a}}\right) + Q_a^t R_a\left(1 - e^{-\frac{\Delta t}{R_a C_a}}\right) - T_{u,\text{in}}^{t-1} e^{-\frac{\Delta t}{R_u C_u}}, \tag{6}$$

where $T_{a,\text{out}}$ is the ambient temperature, R_a and R_u are thermal resistance and thermal capacitance, respectively, Q_a^t is thermal power. It is habitable when the temperature is between the minimum temperature $T_{a,\text{in.min}}$ and maximum temperature $T_{a,\text{in.max}}$ set by the user. Therefore, its constraints are as in the following formula (7).

$$T_{a,\text{in.min}} \leqslant T_{u,\text{in}}^t \leqslant T_{a,\text{in.max}}, \quad \forall t \in T_a. \tag{7}$$

Temperature-controlled load energy management is an algorithm to find the minimum point, focusing on the analytical formula for temperature-controlled load power consumption and electricity bills. Therefore, combined with the definition of price elasticity of Formula (9), the self-elasticity and cross-elasticity of the temperature-controlled load price demanded by user u at node n can be obtained.

$$\alpha_{n,u}^{t,i} = \frac{\Delta D_{n,u}^{i}}{\Delta \lambda_n^t}. \tag{8}$$

Generally speaking, users usually have a stable power consumption inertia. Therefore, it can be assumed that the price elasticity of demand for temperature-controlled loads does not change in the short term.

$$k_{3,\text{com}} = \frac{1}{W_a}\left(1 - e^{-\frac{W_a}{Y_a}\Delta t}\right). \tag{9}$$

$$k_{3,\text{res}} = \eta_a R_a \left(1 - e^{-\frac{\Delta t}{R_a C_a}}\right). \tag{10}$$

After the electricity price rises, the demand for temperature-controlled loads is not reduced or transferred, but it damages the profits of users. Likewise, the demand for temperature-controlled loads does not increase or shift further after the electricity price cut, but instead harms the interests of the grid or the independent system operator.

3.3 Aggregate response algorithm based on multi-modal temperature control load

The kernel density estimation is shown in the following formula (11).

$$\hat{f}_{h_{R_0}}(R_a) = \frac{1}{n_s h_{R_a}} \sum_{i=1}^{n} K\left(\frac{R_a - R_a^i}{h}\right), \tag{11}$$

where n_s is the number of user samples, h is the bandwidth, $K(\cdot)$ is the kernel function, and $K(\cdot)$ and h_{R_a} are defined as follows:

$$K(x) = \frac{1}{(2\pi)^{\frac{n}{2}}} \exp\left(-\frac{x^2}{2}\right), \tag{12}$$

$$h_{R_a} = \left(\frac{4}{3n}\right)^{\frac{1}{5}} \hat{\sigma}_{R_a}, \tag{13}$$

where $\hat{\sigma}_{R_a}$ is the standard deviation.

Finally, the price elasticity formula of user demand can be obtained.

$$\hat{\alpha}_n^{t,i} = \left\{\hat{\alpha}_{n,\text{com}}^{1,i}, \hat{\alpha}_{n,\text{res}}^{1,i}\right\}, \tag{14}$$

$$\hat{\alpha}_{n,\text{com}}^{1,i} = N_{\text{com}} \cdot \bar{\alpha}_{n,\text{com}}^{1,i}, \tag{15}$$

$$\hat{\alpha}_{n,\text{res}}^{t,i} = N_{\text{res}} \cdot \bar{\alpha}_{n,\text{res}}^{t,i}, \tag{16}$$

where N_{com} is the total number of industrial and commercial groups, and N_{res} is the total number of user groups.

4 Realization and Testing of Intelligent Temperature Control Load Energy Saving Technology

After completing the research on the multi-modal temperature control load energy saving technology, experiments are carried out to verify the effect of the load energy saving theory technology. Air conditioners and electric water heaters are commonly used home appliances, and their PL power consumption and temperature characteristics are obvious. Therefore, the air conditioners and electric water heaters in the power grid system of an industrial and commercial user are selected as experimental objects to test the effectiveness of the temperature-controlled load energy-saving technology.

First, the power consumption of the air-conditioning PL is tested and simulated, and the changes of the air-conditioning PL power before and after optimization are analyzed successively. Then, its simulated graph is calculated and drawn. The particle swarm optimization algorithm is selected to calculate the power optimal dispatch model, and the original load curve and the optimal load curve obtained by the optimal dispatch are analyzed. The PL simulation results are shown in Figure 4.

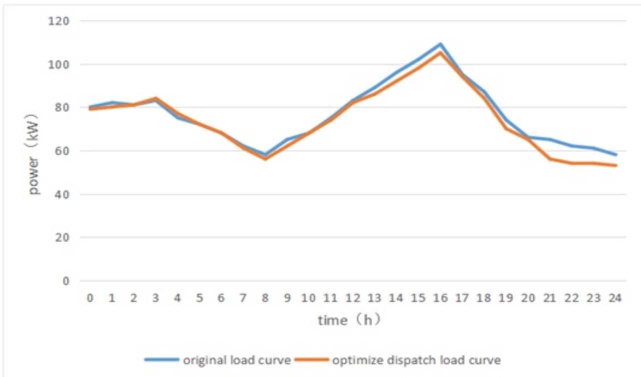

Figure 4. Air conditioner PL time power curve.

It can be easily seen from Figure 4 that after optimizing the electrical load of the air conditioner, its power in $0-8$ hours is almost the same as before. However, the electrical load power after $9-24$ hours is less than the original case. The 24-hour total power consumption before and after the air conditioning optimization is 1916kW and 1855kW respectively, and the total power has decreased by 61kW. This shows that the PL energy saving technology can effectively reduce the PL power of the air conditioner. It shows from the side that this technology can be applied to the user's air conditioning power optimization.

In addition, the analysis and experiment of air conditioning PL power and temperature should be carried out. Similarly, successive experiments are used to analyze the air-conditioning PL power and chassis temperature before and after optimization. Then, it is calculated and its simulation curve is drawn. The results are shown in Figure 5.

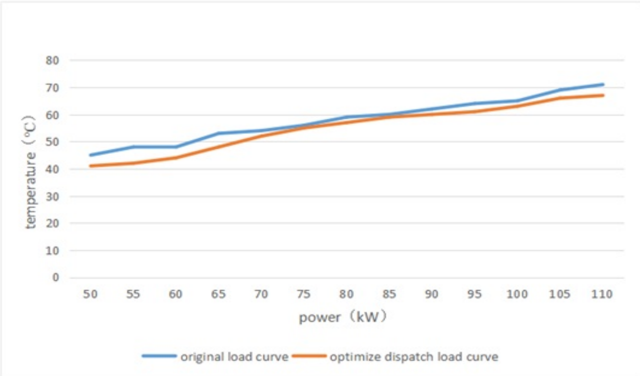

Figure 5. Air conditioner PL power temperature curve.

It can be easily seen from Figure 5 that before and after the optimization of the air conditioner, the surface temperature of the air conditioner case increases with the increase of the power. However, after optimizing the PL of the air conditioner, its temperature at various power levels is lower than that of the previous air conditioner without optimization. The average temperatures (AT) of the air conditioners before and after PL optimization are 58°C and 55°C, respectively, and the temperature has dropped by 3°C. This shows that the PL energy saving technology can effectively reduce the PL temperature of the air conditioner. It shows from the side that this technology can be applied to the user's air conditioning power optimization.

After that, the above-mentioned air-conditioning PL scheduling curve is analyzed. Combined with the user satisfaction survey, the data collected from these analysis and surveys are counted, and an air-conditioning PL effect evaluation table was made. The results are shown in Table 1.

Table 1. Influence diagram of PL power temperature curve.

	Before PL optimization	After PL optimization
24 h total power (kW)	1916	1855
Operating AT (°C)	58	55
customer satisfaction(%)	84.2	91.4

The temperature control load characteristics of electric water heaters are also very obvious, which is very suitable for electric load related experiments. Therefore, the same method is used to simulate and analyze the load power and temperature of the electric water heater. Combined with user satisfaction surveys, the resulting data is integrated and analyzed. Electricity load effect evaluation table of electric water heater is made. The results are shown in Table 2.

Table 2. Influence diagram of PL power temperature curve.

	Before PL optimization	After PL optimization
24 h total power (kW)	1311	1274
Operating AT (°C)	64	59
customer satisfaction(%)	85.7	92.1

It can be easily seen from Table 2 that the total power consumption of the electric water heater before and after PL optimization is 1311kW and 1274kW, respectively, and the total power has decreased by 37kW. The average temperatures are 64°C and 59°C, respectively, with a temperature drop of 5°C. This shows that the PL energy-saving technology can not only effectively reduce the power consumption of the electric water heater during operation, but also effectively reduce the PL temperature of the electric water heater. It shows from the side that this technology can be applied to the power optimization of the user's electric water heater.

It can be seen from the above two main household appliance experiments that PL optimization and energy-saving technology can effectively reduce the power consumption and temperature of electrical products. In addition, from the perspective of whole grid energy management, power optimal dispatch is to comprehensively evaluate the transferable energy of each module load on the demand side. It can calculate the power energy and allocate the size of the power index according to the specific target. The optimal dispatch of electric power energy can provide the optimal energy distribution strategy and real-time control strategy to improve the energy efficiency and utilization rate of electrical equipment, so as to achieve the goals of improving the load characteristics of the power grid and improving the reliability of the power grid operation.

5 Conclusion

The intelligent temperature control load energy-saving technology technology based on multi-modal target detection, recognition and tracking technology not only improves the energy efficiency of electrical loads, but also effectively reduces the temperature of electrical appliances during operation. It has a remarkable effect in the experiment of energy saving of electrical load. This study believed that after using the technology of intelligent temperature control load energy saving technology, the operating power and operating temperature of the entire electrical appliance have undergone relatively obvious changes. The continuous operating power consumption of the electrical appliance was lower, and its operating temperature had also decreased. This temperature-controlled load energy-saving technology reduces the operating power consumption of household appliances and saves power energy by providing a good power-saving mode. In addition, the operating temperature of the electrical appliance has been lowered. The pressure of the electrical appliance when it is running for a long time has been reduced, and the service life of the electrical appliance has been prolonged. The temperature-controlled load energy-saving technology based on multi-modal target detection, recognition and tracking has effectively reduced the power consumption and temperature during the operation of electrical appliances. However, this system has a shortcoming, that is, it needs strong processing ability to process complex energy information, analyze various information in different external environments, so that the best operating mode of the current environment can be obtained. Therefore, in order to support the operation of this temperature-controlled load energy-saving technology, a powerful processor is required. Therefore, this system is not suitable for power companies with poor processors. This is the shortcoming of the intelligent temperature control load energy saving technology. The advantages of high efficiency, stability and immediacy of this temperature-controlled load energy-saving technology far exceed those of traditional power energy-saving technology. However, the hardware requirements of the current processing module are relatively high, so it is not suitable for most users in the current price segment. For users, the internal processor, as the brain for processing power energy information, has played a vital role in the entire power saving process. If the hardware conditions are difficult to guarantee, it is difficult for this PL energy saving technology to ensure smooth operation. However, it is believed that with the progress of society and the development of science and technology, in the near future, hardware would no longer be the shackles of science and technology. Therefore, in the future, the traditional PL temperature control energy-saving technology would be combined with the multi-modal target detection, identification and tracking technology to realize the hybrid intelligent temperature control load energy-saving technology processing technology. Electric power energy-saving technology has been further advanced, and the development of PL temperature control and energy-saving processing technology is driven by informatization.

Data Availability Statement

Data will be made available on request.

Funding

This work was supported in part by the Ordos Science and Technology Plan Project under Grant 2022YY041; in part by the Inner Mongolia Natural Science Fund Project under Grant 2019MS06013; in part by the Hunan Enterprise Science and Technology Commissioner Program under Grant 2021GK5042.

Conflicts of Interest

Changgui Shan is an employee of Nanjing Lishuangde Mechanical and Electrical Equipment Installation Co., Ltd., Nanjing 210008, China

Ethical Approval and Consent to Participate

Not applicable.

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