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Household Small Solar Energy Storage Device

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Summary

In this article, we will reuse the batteries that have been eliminated from the use of electric vehicles for certain periods of time. This paper designed a kind of device, the device can store electrical energy from solar energy and electricity from the grid into a battery pack. At the same time, the device can make full use of the electricity generated by solar energy by predicting the future generation of power generation and the classification management of household appliances.

Keywords: photovoltaic, solar energy, electronic, control system, power management

1 Introduction

As people to pay more and more attention to environmental problem, more and more people obtain energy by means of renewable clean energy nowadays. We often see street lights powered by solar and wind power along the road. At the same time solar energy and wind energy are widely used all over the world. However, at present the main construction area of solar and wind energy is still in the open area away from the city. Electricity generated by renewable energy is transmitted into homes through power lines.In this way, not only geographical restrictions are received, but also long distance power transmission will have considerable power consumption.As a result, renewable energy sources can not be fully utilized. So it's better to design energy directly for electricity at home by generating electricity from renewable sources of energy. Compared to several new energy sources, solar energy is the most direct, reliable and simple way for families to obtain energy.

Therefore, this article puts forward a kind of household small solar energy storage device. The device can generate electricity through the solar panel and store the electric energy generated by the solar energy into the battery package, and then pass the battery pack through the inverter to supply power to the appliance in the household. There is also a prediction of solar power generation in the device and determine the best economic benefits based on projected electricity generation and the household appliances are classified and managed according to the different nature. So as to make full use of the energy produced by solar energy.

2 Hardware Design

The purpose of this paper is to make full and rational use of the electricity energy obtained by solar panels. Therefore, in the design of hardware, it is necessary to use more efficient converters and classify the electrical energy according to the different loads. The overall hardware design of the system is shown in Figure 2.1. In this system, BMS and master board and inverter are controlled by 16 bit microcontroller MC9S12XEG128. The maximum power point tracking of solar panels is achieved by BMS control and DC/AC is a grid connected inverte and the battery pack uses 48V lithium ion battery. All relay switches in the diagram, K1, K2, S1, S2, S3 and KL1~KL6 are all controlled by the main control panel. KL1~KL6 contains two sets of relay switches, one is to control the power grid access, and the other is to control the access of the inverter. When two groups of switches need to be closed at the same time, the condition of the grid connection shall be determined first and then closed if allowed. All the energy outputs in the circuit include fuse protection.

2.1 Operating Mode

According to Figure2.1, there has three operating modes are as follows:

Mode 1: In the case of sunlight, the power generated by the PV component is boosted by the BOOST converter and charged into the battery pack. The battery pack transforms the electrical energy through the DC/AC and supplies power to the home AC load or changes the electrical energy through the DC/DC buck converter to power the home DC load. Under this working condition, the BOOST converter, the DC/AC boost inverter and the DC/DC buck converter are in the working state, and the AC load relay S2 and the DC load relay S3 are closed;
Mode 2: The electrical energy obtained in the grid is charged by the AC/DC buck converter to charge the battery pack. The battery pack converts the electrical energy through the DC/AC boost inverter to power the home AC load, or converts the electrical energy to the home DC load via the DC/DC buck converter.Under this working condition, the AC/DC buck rectifier, the DC/AC boost inverter and the DC/DC buck converter are in the working state, and the AC load relay S2 and the DC load relay S3 are closed;
Mode 3: The electric energy obtained in the network can directly supply power to the domestic AC load. In this working state, the electrical connection part of the power grid relay S1 is closed.

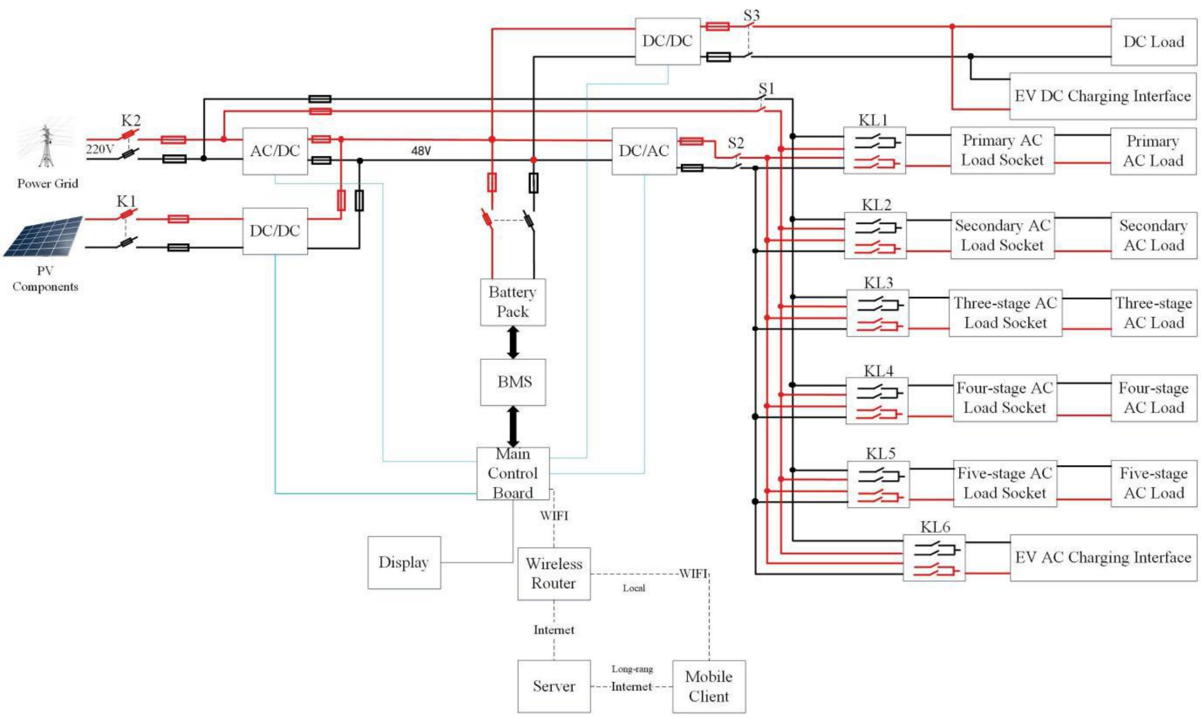

Figure 2.1: System block diagram

The voltage output of the DC/DC converter in Figure 2.1 can be adjusted by the display so that it can be set according to the load. For example, when the USB data line is used to charge the mobile phone, the voltage is different from the voltage level charged to the electric vehicle. Thus, charging of different loads can be charged by varying the voltage.

2.2 AC Load Classification

Load classification is designed to maximize the use of solar energy by varying the management of different electrical appliances. For example, when the SOC of the battery is less than 20%, it is not enough to keep the refrigerator working on cloudy days. Electricity is needed to power the refrigerator through the grid. But the food in the fridge doesn't go bad because the fridge doesn't work in two hours. Therefore, according to the forecast of PV generation in the next two hours, the power supply mode of the refrigerator can be determined. If the weather becomes clear after 2 hours, the PV power generation will be enough for the refrigerator, and the power to the refrigerator can be temporarily stopped, and the refrigerator will be powered again after two hours.For electric appliances such as light bulbs, they must be in use immediately, so whether or not the PV component can generate electricity in the future is required to power the light.

The primary ac load is passed by the relay KL1 and the secondary ac load is passed by the relay KL2 and so on. The relay KL1~KL6 are controlled through the main control board, the front end is connected to the inverter on the grid, and the back end is connected to the load.

The following is the classification of commonly used appliances, and of course, the main control board can be changed to different levels of load control strategy through the setting of the display screen.

Primary ac load: hot water kettles, electric rice cooker, air conditioner and other high-power appliances;

Secondary ac load: TV, computer, living room and bedroom entertainment appliances;

Three-stage ac load: electrical appliances that require continuous power supply;

Four-stage ac load: lighting system and emergency electrical appliances;

Five-stage ac load: water heater type energy storage appliance.

3 Algorithm

In order to make full use of the electricity produced by solar panels, it is necessary to predict the amount of electricity produced by solar energy to meet the needs of everyday life for electrical appliances.According to the predicted power generation, the energy can be rationally stored and allocated.Reliable algorithms are therefore needed to predict power generation. But as global warming and air quality become worse, the ability of solar panels to generate electrical energy will change as the environment changes. Therefore, when the algorithm is only used in a fixed form of expression, the prediction can not be accurate and reliable expression. Therefore, the algorithm needs to be able to change the coefficients according to the amount of data, so as to achieve the highest reliability.

3.1 Prediction of Photovoltaic Power Generation Based on BP Neural Network

There are many factors affecting the maximum power point of PV modules in the process of power generation and the most important one is the intensity of illumination. As the weather changes, the light received by the PV components is different on a clear day, cloudy day or rainy day, so that the power generated by the PV components at the same time is different. At the same time, as the seasons change, the angle of the sun changes and the most prominent of which is the temperature. The power generation in unit time is a very complex nonlinear system, so it is difficult to model accurately by mathematical method. Therefore, the BP neural network can be used to express the nonlinear system. The method is to look at the model as a black box. Firstly, the BP neural network is trained by input and output data, so that the BP neural network can express the position function. Then the trained BP neural network is used to predict the output of the system. Figure 3.1 shows the flow chart of the algorithm. In order to get better results, it is necessary to train more than once.

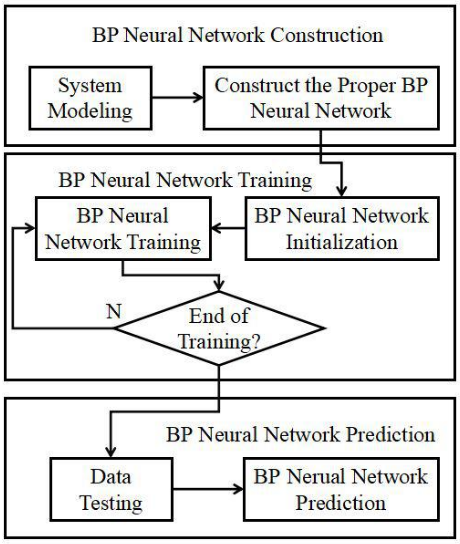

Figure 3.1: Algorithm flow

The output layer has m neurons, the actual output of BP network is y, and the expected output y' function is:

$$\varepsilon = \frac{1}{2}\sum_{j=1}^{m}(y_j - y_j^{'})^2 \tag{3.1}$$

The revision of each weight value is:

$$\Delta\omega_{ij} = -\eta\frac{\partial\varepsilon}{\partial\omega_{ij}} = -\eta\frac{\partial\varepsilon}{\partial I_j}\frac{\partial I_j}{\partial\omega_{ij}} \tag{3.2}$$

In the formula: ω_{ij} is the weight of the input cell i to the hidden layer element j; η is the learning rate, and I_j is the transfer function of the intermediate j hidden layer. The function of the input layer to the implicit layer adopts the $Logsig$ type, the implicit layer to the output layer to use the $Purelin$ type.

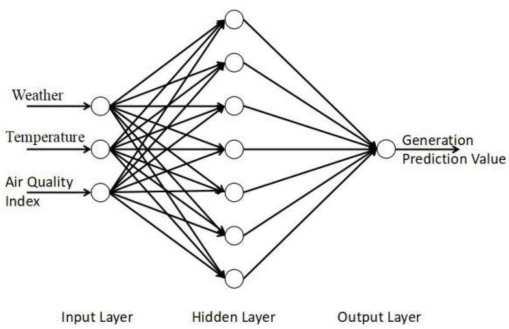

Figure 3.2: Topological graph of BP neural networks model

The main control factors of solar power generation are weather, temperature and air quality, and these three factors are input parameters of neural network model. Therefore, the input endpoint is 3 and the output endpoint is 1. Because the input endpoint is 3 and the output endpoint is 1, According to the selection of the number of nodes in the hidden layer, the number of nodes in the hidden layer is chosen as 7. TTherefore, the BP neural network structure is 3-7-1, and the structure diagram is shown in Figure 3.2.

Before BP neural network training, in order to weaken the influence of different dimension data of each master factor on network model training and prediction value, the data of main control factors are normalized.

3.2 The Thought Evolution Algorithm Optimizes BP Neural Network

With the development of computer science, with the help of the survival of the fittest, people combine computer science and biological evolution to develop a heuristic random search algorithm, that is, mind evolutionary algorithm.

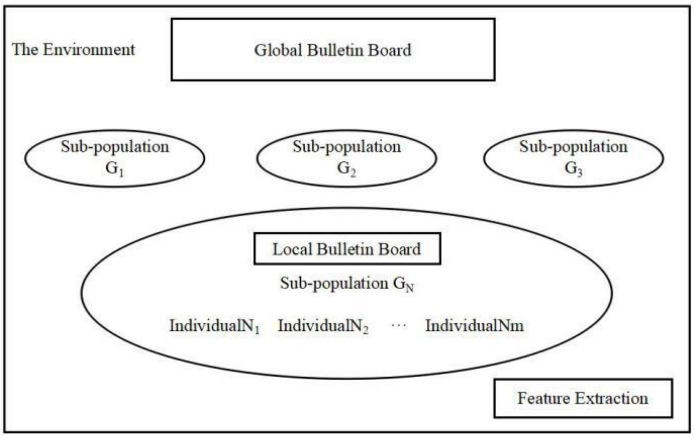

Figure 3.3: Mind Evolutionary Algorithm System Structure Diagram

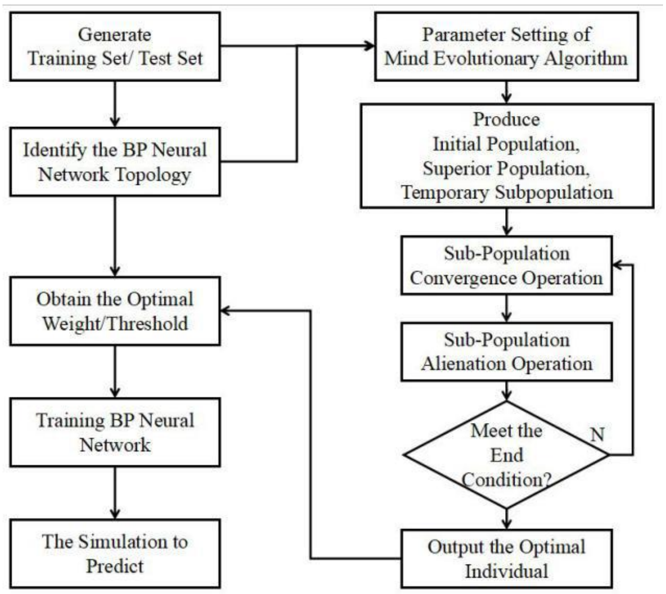

Figure 3.4: Design Procedure Flow Chart

BP neural network can predict the future power generation, but the convergence is slow and the error is greater, so it is necessary to optimize the weights and thresholds of the BP neural network through the thinking evolution algorithm. Here, we select the same network structure as the previous section, and select the reciprocal of mean square error of the training set as the scoring function of each individual and population. After iteration, the optimal individual is output, and the initial weights and thresholds are determined according to the optimal individual.

4 Verification and Analysis

In order to ensure the reliability of the algorithm, the feasibility of BP neural network optimization based on mind evolutionary algorithm is illustrated by 200W photovoltaic power generation system. Photovoltaic power generation system 6~8 months of photovoltaic power generation data as an example.We can get a graph as shown in figure 4.1.

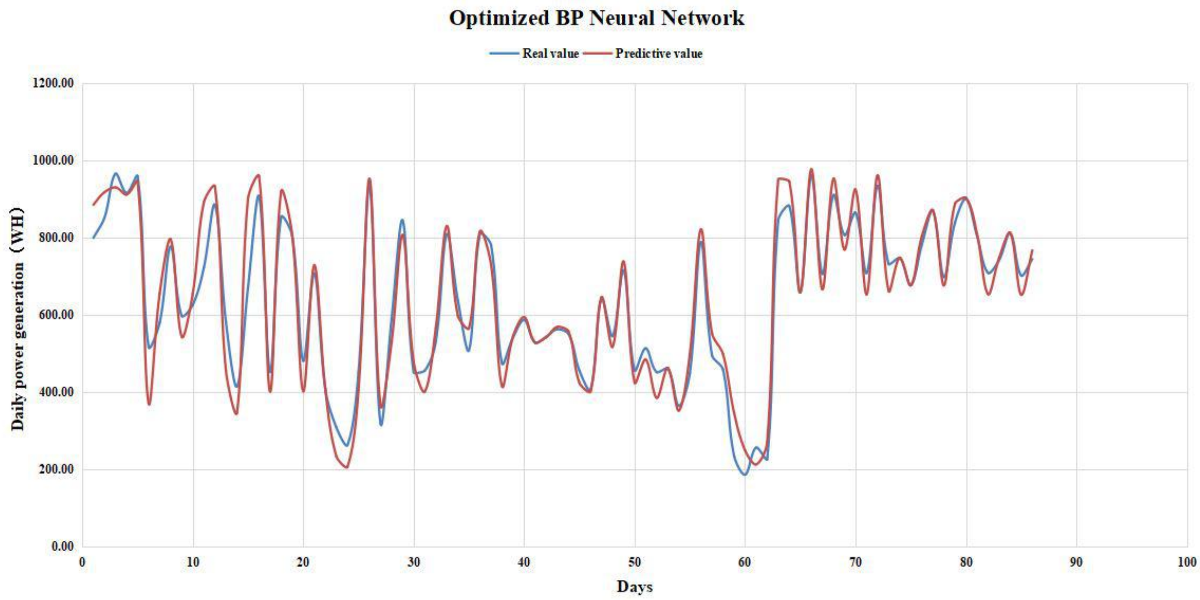

Figure 4.1: Comparison of Real and Predicted Values

Blue in figure 4.1 for the actual photovoltaic power generation, while the red for the prediction of photovoltaic power generation, abscissa for days, the vertical units for WH, it's not hard to see from the picture prediction of photovoltaic power generation and photovoltaic power generation is very close to real, and the real value on the changing trend of which is similar.However, the difference between pv power generation and real pv power generation is not known by figure 4.1. So figure 4.2 shows the error between the two.

It is not hard to see from figure 4.2, at the start of the prediction, the predicted value is very unstable relative to the real value and fluctuates greatly, which is very close to the real value. After 18 days, the error between the predicted and the true values is reduced and the range of fluctuations is reduced to -50WH-50WH. This shows that as the data increases, the predicted value is closer to the real value. When fortieth days are carried out, the error between the predicted value and the true value is obviously reduced, and the error range is less than 10WH. In the next few days, the predicted and true values fluctuate somewhat, but the fluctuations are within a reasonable range, indicating the convergence between the predicted and the real values. But after fifty-fifth days, the error between the predicted value and the true value is obviously increased, and the error amplitude fluctuates greatly. The weather observation during this period found more will cause a lot of cumulonimbus thunderstorm weather in a short time. Therefore, the normal operation of the photovoltaic system will be affected in a short time, so that the predicted value will occur in the true value, the phenomenon of greater errors

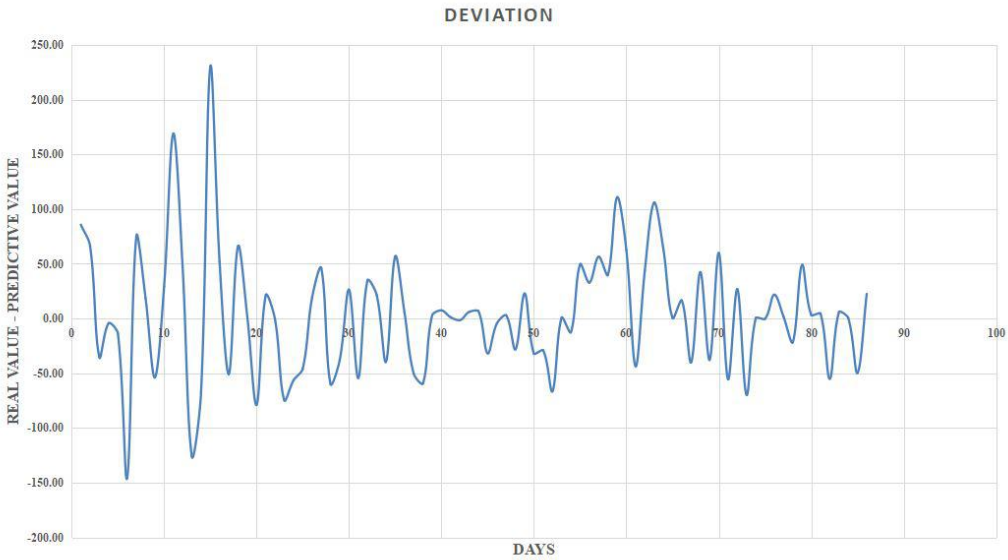

Figure 4.2: The deviation between the real value and predicted value

So the BP neural network algorithm thinking evolutionary optimization in sunny weather and based on training data can have certain prediction value is close to the true value, and with the increase of data quantity, the error decreases. However, the abrupt change of weather phenomena can not be very close to the true value. But for the abrupt change of weather, there is not enough data to train the algorithm, and it can not be very close to the real value.

5 Software Design

The prediction of solar panel power generation, the optimization of the algorithm and the decision of scheduling need to be carried out through the CPU in the main control panel. Therefore, we need to burn programs in CPU so that the device can perform the above functions on its own. The main control board using CPU is Freescale Carle 12 bit microcontroller MC9S12XEG128, and the software compiler environment used by Freescale Carle developed CodeWarrior for S12 V5.1, and compiled language for C language. The true value of the solar panel power generation is measured and recorded by BMS and transmitted to the main control board through CAN communication. The power consumption is collected by ADE7755, a high-precision single-phase power measuring chip produced by ADI company. The ADE7755 chip is placed in the relay of each control load energized state and transmitted to the main control board through pulse data. The main control board is connected to the WiFi module through the serial port, and then sends the access instruction to the API interface of the National Weather administration through the router, and extracts the weather forecast information from the returned data. The software also includes the normal work of the relevant parts of the hardware.

5.1 Input Scheduling

The scheduling of the input is the scheduling of the acquired power mode. In this paper, the power supply can be supplied in three ways, namely, solar battery load, grid battery load, and grid load. Therefore, it is necessary to calculate the time and which way to obtain the electrical energy.

The execution of the dispatching selection is determined by the CPU in the main control panel, and the switch states of the relays K1, K2, S1 and S2 are selected to determine the mode of obtaining electrical energy. As shown in Figure 5.1, the weather forecasts are obtained via the Internet, and the future power generation of the solar panels is predicted from the algorithms mentioned in the fourth chapter. The purpose of the energy storage device mentioned in this paper is to make full use of solar energy for power grid peak shaving and valley filling. Therefore, the battery pack is charged only when the power grid price is in the trough phase. The charge depends on the current battery package, SOC, and the forecast of the user's power consumption. By calculation, the power can meet the normal power usage for second days.

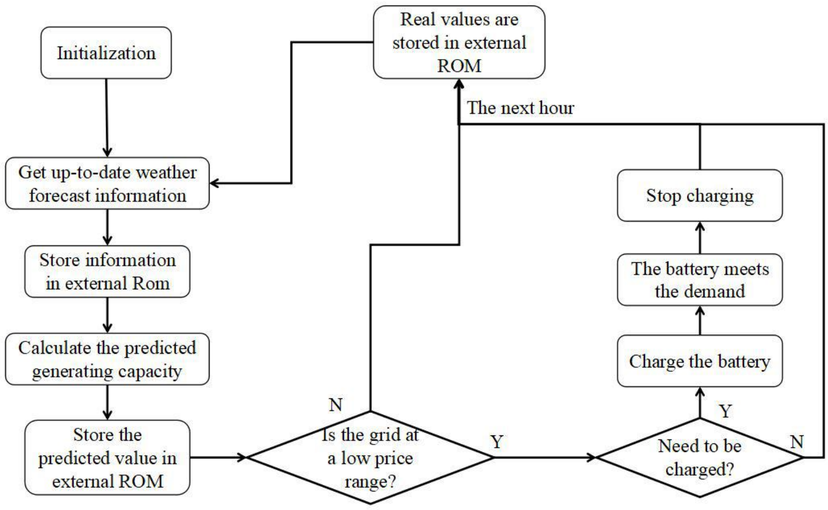

Figure 5.1: Input terminal scheduling policy flow chart

5.2 Output Scheduling

Output scheduling refers to the power supply control of five levels of AC load and DC load. Since each of the five levels of load has different control strategies for each level of load, it is necessary to plan different levels of control over five levels of load.

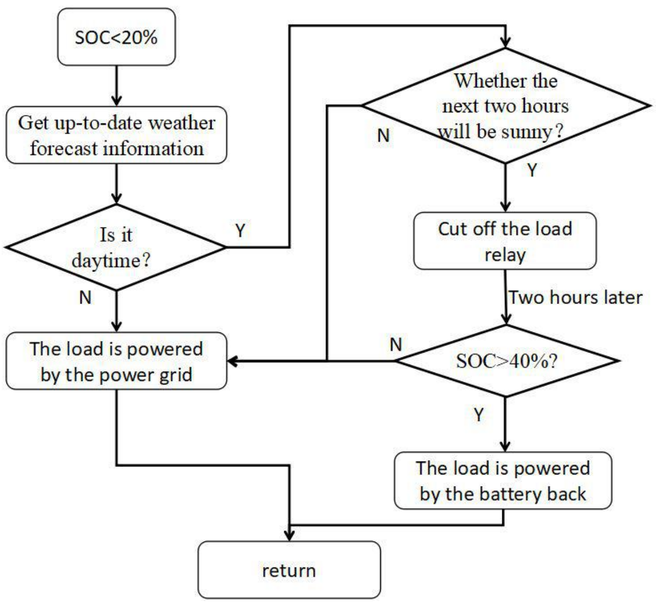

Figure 5.2: Output terminal scheduling policy flow chart

The output scheduling is also controlled by the CPU in the main control panel. Determine the level of power to load by determining the turn-on and turn off of the KL1~KL6 and the S3. For example, Figure 5.2 is a flow chart of a power supply strategy for the level of a refrigerator. Because the fridge doesn't work for two hours, the food in the fridge doesn't go bad. So, when the battery pack is low, you can wait for the solar panel to charge it for a period of time, then power the refrigerator. Therefore, when the battery pack SOC is less than 20%, when scheduling this level load, the solar panel can determine whether the power generation is normal, and then decide which way to supply the load.

The scheduling policy shown in Figure 5.2 is only one of the load levels, and there are different control strategies at different levels of load.

5.3 Algorithm Optimization

As the atmosphere changes and the greenhouse effect rises year by year, the environment facing the unit will change year by year, and each season, even every month, will have different weather changes. Therefore, a single algorithm is not able to meet the impact of the daily change of the environment on the prediction quantity. Therefore, it is necessary for the device itself to adjust its algorithm to deal with the change of environment, so as to improve the prediction accuracy.

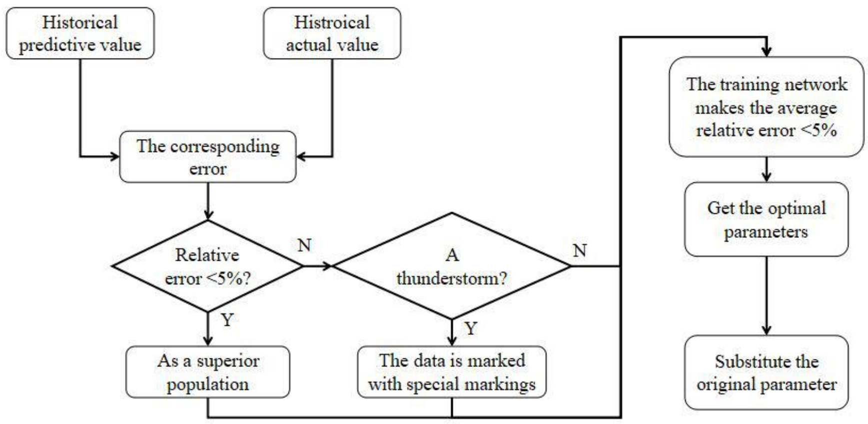

Figure 5.3: Algorithm optimization flow chart

Algorithm is optimized by a large amount of historical data for the reference, by comparing the predicted values and the real value history which predicted values and real values to select the most close, and as a good forecast data, parameter changes for the next step for the reference. At the same time, because there are often short thunder storm weather in the summer, which can make the error of the predicted values and the real value is bigger, so will thunder storm weather data for special marks, focusing on parameter identification of thunder storm weather. Then through a large number of historical data verification, continuous training network, get the optimal parameters to replace the original parameters.

6 Conclusion

To sum up, this article referred to in the home small solar energy storage device can not only reduce the peak power load impact to power grid. At the same time, according to the user's electricity habits improve the system, make full use of solar energy. However, from the solar power generation forecast results, the error is still obvious, and can not be aimed at thunderstorms and other weather accurate generation forecast. When the weather condition is sunny and the weather is stable, the predicted value approaches the real value. But with the increase of weather instability, the error between the predicted value and the true value will increase. On the other hand, the weather varies considerably during the year because of the different seasons. Therefore, the current amount of experimental data is far from enough. Only after a large amount of data has been verified for a long time can we reach an accurate and rigorous conclusion.

Household small solar energy storage device is not only suitable for electric power supply. Because 48V lithium-ion batteries occupy little space and relatively light. Therefore, they can be used outdoors camping and produce food through electric ovens instead of getting heat by carbon. At the same time, the device can also be arranged in a refrigerated and constant temperature demand transportation vehicle to reduce the consumption of fuel on the internal-combustion engine so as to save energy and reduce emission.

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