The problem of energy shortage has become one of the most serious problems in the process of economic development. The research is aimed at studying the energy conservation data and information model of large public buildings. Based on the theories of 5G technology, embedded system, and energy conservation of large public buildings, firstly, 5G technology is used to collect research data. Secondly, some large public buildings in Northwest China are analyzed for energy conservation by using ZigBee and other related technologies and algorithms. Finally, the office buildings in large public buildings are used as samples for the construction of the information model to be analyzed. The research results denote that large public buildings are mainly concentrated in hospitals, hotels, shopping malls, and so on. The south-facing window to wall ratio is higher than that of the north-facing window to wall ratio, and the east-west-facing window to wall ratio has the lowest probability of appearing. In addition, the thermal conductivity of the roof of most of the large buildings is less than 1.0 W, while the thermal conductivity of the outer wall of the roof is distributed around 2.5 W, and the thermal conductivity of the outer wall is around 0.6 W. Finally, commercial buildings have higher heating and cooling loads than residential buildings. In the construction of the information model for energy conservation of large public buildings, the neural networks (NNs) and clustering analysis algorithm are introduced into the prediction model of energy consumption data, and it is found that compared with the actual observed value, the overall trend shows consistency, both of which are periodic fluctuations. However, there are still some errors in some data. Therefore, an analysis of energy conservation data of embedded large public buildings and the construction of information models based on 5G has important guiding significance for the construction industry to improve business performance and market competitiveness.
Liu et al. analyzed the energy conservation potential of existing large buildings in the city and the expected effect of potential energy conservation measures and found that the main factors affecting their energy conservation are the type of the building, the physical parameters of the building, the available technologies of reconstruction, the energy-using behavior of the building, and the standard level of energy savings. In addition, it also studied the complexity and comprehensiveness of the implementation system of large public building reconstruction and proposed optimized implementation strategies and incentive policies, to achieve the control goals of the total energy consumption, energy intensity, and energy efficiency level of regional buildings [4]. Moshi et al. introduced 5G embedded technology and clustering algorithms into the energy conservation engineering of large public buildings and developed a model for information construction to evaluate the energy conservation reconstruction potential and energy efficiency level of classified buildings [5]. Qian et al. introduced the method of multiobjective optimization into the construction of the information model and discussed the current concept of energy conservation reconstruction of large buildings. Based on this, a multiobjective optimization model of energy conservation of building and net present value (NPV) to the greatest extent is proposed. The dynamic optimization strategy of energy conservation measures is studied to reflect the changes in the time, building, and technical dimensions of energy conservation reconstruction of large public buildings [6]. Lee et al. used the Monte Carlo method to simulate the classified regional energy load and then proposed the peak accumulation distribution of the regional cooling load in the design stage, which provided a theoretical method for the selection of public areas [7]. Liu and Ren took 120 public buildings of three provinces in Northwest China as research samples, analyzed their energy consumption within one month, and simulated the system performance in buildings by solving the dynamic heat balance equation through a transient simulation model with the support of 5G technology. The research found that the transient simulation model can be used for highly detailed modeling of buildings and control systems. Under the constraints of total energy consumption of buildings, the design and the energy efficiency evaluation of specific energy consumption systems are carried out [8]. Liu et al. studied the energy system of typical large public buildings and put forward the concept and model of energy conservation reconstruction of the whole process of sustainable buildings in the future. It starts from the preliminary preparation and demand for the reconstruction of large public buildings, the design of the reconstruction plan, the optimization of the reconstruction plan, the implementation of decision-making in the energy conservation reconstruction, and the evaluation and continuous improvement after the energy conservation reconstruction. This process can provide certain ideas and methods for the construction of modern smart cities [9].

The above experts and scholars have expounded the relevant theories on the research of analysis of energy conservation data of public buildings and construction of the information model from different perspectives. However, it is difficult to implement in real life and requires professional technical personnel to solve it, and the operability is not strong. Furthermore, the detailed steps for realizing energy conservation operation of large public buildings in the future have not yet been explained. In view of these, based on 5G and embedded systems, some large public buildings in Northwest China are taken as the analysis samples of energy consumption big data. Taking the electricity consumption data of an office area in January as a sample of the information model research and taking neural networks (NNs) and Ethernet technology as the research methods, the two kinds of data are deeply analyzed. Corresponding conclusions are drawn from different perspectives. The purpose is to study the energy conservation of large public buildings in the context of 5G and provide methodological references for promoting the long-term development of the construction industry. Its innovation lies in that it first proposes an embedded system framework for energy consumption monitoring in large public buildings, designs wireless monitoring terminals and gateway nodes based on ZigBee technology, and optimizes the transmission method of original and traditional wired data. Secondly, an energy consumption prediction model of large public buildings based on a neural network is established, which improves the accuracy of energy consumption prediction.

2. Materials and Methods

2.1. Embedded System. An embedded system consists of hardware and software and is a device that can operate independently. Its software content includes two kinds, namely, software operating environment and operating system. The hardware content includes many aspects such as signal processor, memory, and communication module [10, 11]. Compared with the general computer processing system, the embedded system has great differences; it cannot realize the large-capacity storage function, because there is no matching large-capacity medium. Most of the storage medium used has E-PROM, EEPROM, etc. The software part takes the Application Programming Interface (API) as the core of the development platform [12, 13]. Compared with ordinary computers, embedded systems have the features shown in Figure 1.

The software system of the embedded system is designed for the specific hardware system and user requirements of the embedded system. It is a critical part of the embedded system and the key to realizing the function of the embedded system [14–16]. The software system of the embedded system is similar to the general computer software system. It is divided into four layers: driver layer, operating system layer, middleware layer, and application layer, each with its own characteristics [17, 18]. The specific form is shown in Figure 2.

(1) The application layer is mainly used to achieve the software expected by the user. Application software in embedded systems is the most active force, and each application software has a specific application background. Although it is small in scale, it is highly specialized, so embedded application software is not subject to foreign
products like operating systems and supporting software, which is the dominant field of embedded software in China [19]. (2) The middleware layer is the software used to help and support application development, usually composed of databases, network protocols, graphics support, and corresponding development tools [20]. (3) The operating system layer is mainly responsible for the allocation of all hardware and software resources of the embedded system, scheduling work control, and coordinating concurrent activities [21]. (4) The driver layer is a layer that directly deals with hardware, which provides hardware drivers or underlying core support for operating systems and applications. There are generally three types of programs in the driver layer, namely, board-level initialization programs, standard drivers, and application drivers [22]. In actual operation, due to the aging of components, asymmetry of circuit parameters, and other unstable factors, embedded systems often have zero output [23]. In the sensor system using a microcomputer, the method of zero compensation is very simple, and the specific calculation method is shown in

\[ y = kx + y_0 + y_c. \]  

In equation (1), \( x \) is the measured physical quantity, \( k \) means the proportional coefficient, \( y_0 \) represents the zero output, and \( y_c \) denotes the compensation amount of the zero. The zero is stored before the embedded system works normally. At this time, the output calculation method of the embedded sensor system is shown in

\[ y = y_0. \]  

In equation (2), it means that the output value of the embedded system is equal to the zero output value, and the letter is the same as the above equation. The zero output is temporarily stored in the memory unit of the computer, and the calculation method of the compensation amount is shown in

\[ y_c = -y_0. \]  

Equation (3) indicates that the zero compensation amount of the embedded system is equal to the zero output value at this time, and the letters are the same as the above equation. According to equations (2) and (3), it can be
known that the specific calculation method after the embedded system works normally is shown in

\[ y = kx. \] (4)

Equation (4) states that when the embedded system works normally, there is a linear relationship between the zero compensation and the measured physical quantity. The letters in the equation have the same meaning as the above equation.

The zero output of embedded systems often drifts with the change of operating temperature, and the specific expression method is shown in

\[ \Delta y_0 = \alpha_0 \Delta \theta + \alpha_1 \Delta \theta^2 + \cdots + \alpha_n \Delta \theta^n. \] (5)

In equation (5), \( \Delta y_0 \) is the zero temperature drift, \( \alpha_0, \alpha_1, \cdots, \alpha_n \) represent the temperature error coefficient, and \( \Delta \theta \) indicates the difference between the actual operating temperature and the standard temperature.

The logic topology optimization problem of the embedded system can be expressed by the equation, and the specific calculation method is shown in

\[
\min S(x) = \sum_{y} \left[ \sum_{j \in L} t(l_j) + \sum_{n \in N} t(n_i) \right].
\] (6)

In equation (6), \( S(x) \) stands for the total delay of the system. \( t(l_j) \) is the delay on the link \( l_j \). \( t(n_i) \) is the \( n_i \) delay of the node. \( y \) means the set of all data transmission paths. \( L \) is the total link, and \( N \) represents the total node. The reliability calculation method of the link is shown in

\[ E(l_j) = G[a(l_j)]. \] (7)

In equation (7), \( E(l_j) \) manifests the \( l_j \) reliability of the link. \( G \) is the functional relationship between the link reliability and the unit price of the link, and \( a \) illustrates the cost. The specific calculation method of node reliability is shown in

\[ E(m_j) = F[a(m_j)]. \] (8)

In equation (8), \( E(m_j) \) represents the reliability of node \( m_j \) and \( F \) is the functional relationship between node reliability and node cost.

Meanwhile, the calculation method of waiting time for sending in the embedded system is shown in

\[ T(n) = t_m \cdot t_m = t_m - t_n + t_n - t_m. \] (9)

In equation (9), \( T \) means the time, \( n \) is the number, \( m \) shows the group, and \( m' \) refers to the corresponding group of the group. According to equation (9), the calculation method of the average waiting time of the smart sensor can be obtained, as shown in

\[
T(n) = \frac{(n-1)(\gamma + \alpha \beta) + n \alpha (\beta^2 - \beta)}{2(1 - n \alpha \beta)}.
\] (10)

In equation (10), \( T \) means the time, \( n \) is the number, \( \alpha \) is the arrival rate of information, \( \beta \) is the service rate of the service information packet, and \( \gamma \) is the coefficient.

The calculation method of the time required for the grouping of two information groups in the embedded system is shown in

\[
T_{a,b} = \sum_{i=1}^{n} (L_{a,b} + T_{a,b}).
\] (11)

In equation (11), when terminal \( a \) receives the service, the average number of information packets is stored in the memory of terminal \( b \), and the meanings of the remaining letters are the same as the above equation.

The calculation method of the average queuing length of the embedded system in the intelligent online monitoring of the gateway meter is shown in

\[
\mathcal{S} = \frac{\gamma(1 - \alpha \beta)}{1 - \alpha \beta}.
\] (12)

In equation (12), \( \mathcal{S} \) represents the length of queue, \( \alpha \) is the arrival rate of information, \( \beta \) is the service rate of the service information packet, and \( \gamma \) is the coefficient.

When the data information is consistent with the verification and when the embedded system feeds back the information data to the monitoring system, the calculation method of the feedback time is shown in

\[
T(a) = \frac{\alpha \beta(i-j)}{T(a+1)}.
\] (13)

In equation (13), \( T \) means the time, \( i \) and \( j \) refer to the time of sending and of receiving, respectively, and \( a \) represents the \( a \)-th transmission.

2.2 Energy Saving of Large Public Buildings. With the continuous improvement of science and technology, the energy consumption supervision system of large public buildings, as a public information service platform for building energy conservation, provides information services for social public energy conservation and provides support for administrative decision-making. Simultaneously, it plays an active role in building healthy, livable, ecological, and sustainable urban construction goals [24]. The supervision system is mainly composed of four layers, namely, the perception layer, the data acquisition layer, the data preprocessing layer, and the network layer. The specific organizational form is shown in Figure 3.

The network layer mainly transmits the data of the entire operating system, similar to the role of a “bridge” [25]. The normal operation of this layer is inseparable from the strong
Figure 3: The energy consumption supervision system of large public buildings.

Figure 4: The energy conservation big data analysis of large public buildings.
support of Internet of Things (IoT) technology. Due to the complexity, diversity, and real-time characteristics of energy consumption system data of large public buildings, the data preprocessing layer can clean, filter, and collect data to form accurate and effective data [26, 27]. The main function of the data acquisition layer is to collect the relevant and effective information of building energy consumption into the local data set, which improves the efficiency of the staff to a certain extent [28]. The perception layer is the most important part of the energy consumption system of large public buildings. Building energy consumption is a variable affected by building parameters, building environment, and human factors. The perception layer can effectively perceive information such as energy consumption data and environmental data within a specified time [29, 30].

The energy conservation big data of large public buildings includes many different types of buildings, such as schools, shopping malls, hospitals, and railway stations. The data can be summarized into the characteristics of large amount, many types, and high speed. This big data analysis can be divided into four modules: data acquisition, data storage, data analysis, and data application, as shown in Figure 4.

Data acquisition refers to the process of acquiring energy consumption big data, which can be divided into data acquisition, data transmission, and data preprocessing. Data storage refers to the storage and management of energy consumption big data [31]. Energy consumption big data storage includes hardware and software. Data analysis refers to the use of analytical methods or tools to examine, transform, and model energy consumption big data based on the energy consumption data warehouse and explore the relationship between energy consumption changes and internal and external factors such as the environment, building, operating equipment, and personnel activities. The analysis results propose relevant energy conservation measures and formulate relevant energy conservation policies [32]. The data application is based on the energy conservation platform of the large public buildings and realizes the evaluation of energy efficiency, prediction of energy consumption, diagnosis of energy saving, quota of energy consumption, etc. [33]. Clustering analysis and multiple linear regression methods will be used in the construction of energy conservation big data models of large public buildings.

Assuming that the sample size is \( n \), the sample is divided into \( k \) category in a certain clustering analysis, and \( n_i \) is assumed to be the sample size of a certain cluster; then, the proportion of the sample size of this cluster to the entire sample size is shown in

\[
p_i = \frac{n_i}{n} \quad (i = 1, \cdots, k).
\]
Moreover, entropy is a basic concept of information theory. The size of entropy describes the randomness of a random event: the larger the entropy value, the greater the uncertainty of the random event and the more information is given. Otherwise, the smaller the entropy value, the smaller the uncertainty of the event and the less information is given. For a discrete random vector $y = [y_1, \cdots, y_n]$, the specific calculation method is shown in

$$H(y) = -\sum_i p(y) \log_2 p(y). \quad (15)$$

In equation (15), the meanings of the letters are the same as those of the above equation.

Similarly, for a certain clustering, on the premise that the number of clusters $k$ is selected, the entropy of this clustering is shown in

$$H(y) = -\sum_i p_i \log_2 p_i, \quad i = 1, \cdots, k. \quad (16)$$

In equation (16), $p_i$ represents the proportion of the sample size in a certain category to the total sample size, and the remaining letters have the same meaning as the above equation.

A certain clustering is regarded as a complete event group, and each category is regarded as an event in the complete event group, with probability $p_i$. Then, when the probabilities of all categories are equal, that is, when the sample sizes in all categories are equal, the information entropy of the cluster has the maximum value. Written in the form of probability, if $p_i = 1/k$, the entropy of the cluster is the largest, as shown in

$$\max H(y) = -\sum_i \frac{1}{k} \log_2 \frac{1}{k} = -\log_2 \frac{1}{k} = \log_2 k. \quad (17)$$

In equation (17), the meaning of the letters is the same as the above equation.

2.3. Key Energy Consumption Monitoring Technology. (1) ZigBee technology: it is mainly used for data transmission between various electronic devices with short distance, low power consumption, and low transmission rate, as well as typical applications with periodic data, intermittent data, and data transmission with low response time. It has the advantages of low cost, low speed, short distance, low latency, and high capacity. Based on ZigBee wireless network technology, it can optimize the monitoring system of the
Figure 10: Distribution of cooling and heating loads of large buildings: (a) the cooling load and (b) the heating load.

Figure 11: The prediction information model of energy consumption of large public building.
energy consumption system of large public buildings and can receive and send energy consumption data. The specific form is shown in Figure 5.

(2) Ethernet technology is one of the most widely used local area network technologies. Because of the advantages of fast, cheap, high security, and good real-time performance, Ethernet technology has been widely used in the field of building energy consumption monitoring. The text transmission process of its specific energy consumption data is shown in Figure 6.

In the analysis section of the results, some large public buildings in Northwest China are selected for energy conservation analysis, starting from different perspectives such as building area and building function distribution. The building’s different facing window to wall ratio, thermal conductivity, and distribution of cooling and heating loads are discussed. The window to wall ratio of a building refers to the ratio of the window opening area to the unit area in the room (that is, the area enclosed by the building height and the bay positioning line). By analyzing the two indicators of thermal conductivity and cooling and heating load distribution, it can be found to a certain extent whether the energy conservation performance of the building is good.

3. Results and Analysis

3.1. Energy Conservation Big Data Analysis of Embedded Large Public Buildings. Some large public buildings in Northwest China are selected for energy conservation analysis, starting from different perspectives such as building area, building function distribution, and facing window to wall ratio. The specific results are shown in Figure 7.

The area of large public buildings is mainly distributed within 70,000 square meters, and there are very few public buildings over 100,000 square meters. Figure 7 indicates that among many large public buildings, hospitals occupy the largest area, followed by office space, hotels, residences, shopping malls, etc. However, the distribution of building functions is still dominated by residences such as apartments and hotels, followed by offices, hospitals, shopping malls, or markets.

Furthermore, the specific distribution of the window to wall ratio with different orientations is shown in Figure 8.

It can be clearly found from Figure 9 that the south-facing window to wall ratio is more likely to appear than the north-facing window to wall ratio, and the east-west-facing window to wall ratio has the lowest probability of appearing. From this, the windows that can reflect the east-west direction in real life are relatively small.

Besides, ZigBee technology and 5G technology are used to study the current distribution of building thermal conductivity, starting from the heat conduction of building exterior walls, roofs, and exterior windows. The specific results are shown in Figure 9.

ZigBee and 5G technology are applied in the monitoring of the building thermal conductivity system. It indicates that the thermal conductivity of the roof of the majority of large buildings is less than 1.0 W, while the thermal conductivity of the outer wall of the roof is distributed around 2.5 W. In actual life, the thermal conductivity of the outer wall is around 0.6 W. Compared with the thermal conductivity systems of roofs and external walls, the standard deviation of thermal conductivity of external walls is actually larger and the distribution range is wider.

Finally, the cooling and heating loads of large buildings are shown in Figure 10.

Figure 10 shows that in the distribution of cooling and heating loads of large public buildings, the vast majority of cooling loads are concentrated in 0-50 W. As the wattage increases, the load value is smaller, and a small number of buildings are distributed between 100 W and 225 W. The heating load is mainly concentrated between 0 and 60 W, and a few are distributed between 100 W and 150 W. The distribution law of cooling and heating load is generally similar. Corresponding to the situation in real life, the cooling and heating load of commercial buildings is higher than that of residential buildings. The distribution of cooling and heating loads also reflects common sense.

3.2. Construction of the Information Model of Large Public Buildings. First, using the statistical law of regional building energy consumption parameters and using the transfer function method, a stochastic model based on large public building energy demand prediction is established. The specific model framework is shown in Figure 11.

Figure 11 demonstrates that the prediction information model of energy consumption of large public buildings is developed from four aspects, namely, the geometric dimensions of the building, the thermal physical properties of the building, the building behavior and laws, and the climate parameters. In terms of building area, it is mainly based on the area of the building, the form and area of the exterior wall, the form and area of the exterior window, the area of the exterior sunshade, and the height and the number of floors of the building. In terms of the thermal physical properties of the building, it mainly consists of the structural form of the building fence, the thermal conductivity and
thermal inertia of external walls, the number of heat transfer times, and the light transmittance of external windows. In terms of building behavior and laws, it is mainly composed of indoor temperature setting, natural ventilation, and personnel density of building. In terms of climate parameters, it is mainly composed of the average temperature of outdoor dry and wet, basic parameters of solar radiation intensity, and so on.

By ZigBee technology, the energy consumption data of office buildings in large public buildings in January 2021 is selected as the research sample of the information model, and the energy consumption data is shown in Figure 12.

Figure 12 manifests that the energy consumption data of this office building presents a cyclical change rule, with a cycle of about 24 hours. Then, the difference between electricity consumption during nonworking days and working days is relatively large. During the working day, the electricity consumption begins to surge from 7:00 am, and it is always in the peak period of electricity consumption from 10:00 am to 5:00 pm. After 5:00 in the afternoon, the power consumption is slowly decreasing. It means that the results of the data monitored by ZigBee technology are consistent with real life. Based on this, the neural network algorithm and clustering algorithm are used to predict the energy consumption model of large public buildings. The specific situation is shown in Figure 13.

Figure 13 illustrates that the predicted data dimensions are expanded from the aspects of temperature, maximum temperature, minimum temperature, relative humidity, and vapor pressure. During the day, the average wind speed at 0:00 in the evening reaches a maximum of 2.6, and the wind speed at 22:00 is the minimum value of the day. In addition, the highest and lowest temperatures of the day are also concentrated at 0:00 in the evening. In relative humidity, the humidity at night is greater than the humidity in the morning. In the vapor pressure, the maximum vapor pressure of the day also occurs at 8 o’clock in the evening. It can be seen that the above data are generally consistent with the trend of temperature and vapor pressure in daily life.

Finally, the predicted values of the neural network algorithm and the clustering algorithm are compared with the actual measured values, and the specific results are shown in Figure 14.

Figure 14 demonstrates that the actual value is generally consistent with the predicted value, showing a trend of rising and falling volatility, and it is also a cyclical change. However, it is not completely consistent, which means that the neural network algorithm can help the construction of the information model of the energy consumption data of large public buildings to a certain extent, but some small errors still exist. Therefore, in the follow-up research, it is necessary to continue to explore and conduct in-depth analysis.
4. Conclusion

With the continuous improvement of social and economic levels, large public buildings have become “large energy consumers” at the current stage. Based on the embedded system under the background of 5G, energy conservation big data of large public buildings and information model research are carried out, and the following conclusions are mainly drawn: (1) first, some large public buildings in Northwest China are selected to carry out energy conservation analysis. From different perspectives such as building area, building function distribution, and window to wall ratio, it is found that the types of large public buildings are mainly distributed in hospitals, office spaces, hotels, shopping malls, and other places. (2) In the window to wall ratio, the south-facing window to wall ratio has a higher probability of occurrence than the north-facing window to wall ratio, and the east-west facing window to wall ratio has the lowest probability of occurrence. Among the cooling and heating loads, the cooling and heating loads of commercial buildings are higher than those of residential buildings. (3) In the construction of the information model of energy saving in large public buildings, the electricity consumption data of office buildings in large public buildings in January 2021 are selected as the research samples of the information model, and the data results are consistent with the situation in daily life. Moreover, the neural network and clustering analysis algorithm are introduced into the prediction model of energy consumption data, and it shows that compared with the actual observed value, the overall trend is the same, which are all periodic fluctuations. However, there are still some errors in some data. Due to limited energy, there are certain limitations in data acquisition, resulting in some biases in some tests of relevant data. Besides, in the research on energy conservation data analysis of embedded large public buildings and the construction of information models based on 5G, the investment of economic cost is not discussed. Benefit evaluation can be carried out according to the specific situation in the future, so that to a certain extent, it can bring the correct development path for large public buildings.

Data Availability

All data are fully available without restriction.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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