Monitoring Platform of Energy Management System for Smart Community

Li Hui[1], Wang Gui-rong[2], Wei Jian-ping[2], Duan Peiyong[1]

1. Key Laboratory of Renewable Energy Utilization Technologies in Buildings of the National Education Ministry, Shandong Jianzhu University, Jinan, 250101, China
E-mail: lhh@sdjzu.edu.cn, duanpeiyong@sdjzu.edu.cn

2. Shandong Provincial Key Laboratory of Building Energy Saving Technology, Shandong Jianzhu University, Jinan, 250101, China
E-mail: wgrsherry@sdjzu.edu.cn, Wei_Jianping@sdjzu.edu.cn

Abstract: For the purposes of realizing energy-saving and emission reduction for smart community, this paper presents a monitoring platform of energy management system integrated supply energy and using energy for smart community. It monitors, records and analyzes the process data of energy production, energy transmission and energy consumption for smart community. The architecture of community energy system is divided into acquisition layer, transmission layer and management layer. The data communication between data acquisition devices and data center adopts Ethernet and TCP/IP protocol. The data communication between field instruments and data acquisition devices adopts RS-485 interface and Modbus communication protocol. The software system framework of data center is divided into data communication and processing layer, data display and analysis layer and information layer. The development of monitoring platform for smart community can not only improve the management level, but also reduce the energy consumption of community energy system.

Key Words: Monitoring platform, Smart community, Communication protocol, Energy management

1 INTRODUCTION

Energy and environment are the main factors that determine the sustainable development of national economy. The energy-saving of building is an important part of the sustainable development strategy. At present, the building energy consumption is about of 1/4[1] of the total social energy consumption and will gradually increase to 1/3 with the improvement of people's living standards in China [2]. Smart communities are the basic units of smart city. The energy management system of smart community is an important part of smart community. At present, the researchers mainly focus on the studies of energy consumption monitoring for large public buildings[3-5]. Related standards and guidelines of energy consumption monitoring for large public buildings have also introduced in China. However, the monitoring design of energy management system integrated supply energy and using energy for smart community has not been reported. This paper presents a monitoring platform of energy management system for smart community. It monitors, records and analyzes the process data of energy production, energy transmission and energy consumption of the smart community for guiding reasonable running of community energy systems (CES) and realizing energy-saving and reducing pollutant emission. The CES can be divided into supply energy side (SES) and using energy side (UES). The SES mainly includes power energy, cool and heat energy and natural gas. The power energy system typically includes conventional Transformer stations, solar power, wind power and other renewable power energy. The cooling and heating source systems typically include heat transfer stations, refrigeration plant, heat pump plant and solar hot water system. The UES usually is divided according to different buildings, such as residential buildings, office buildings, shopping buildings, sports buildings, hospital building and so on. For residential buildings, the power energy is no longer subdivided and the electricity consumption is measured in every household. For public building, the data measured of power energy can be divided into electricity of light and socket, electricity of air conditioning, power electricity and special electricity.

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2 ARCHITECTURE OF CES

The architecture of CES is divided into acquisition layer, transmission layer and management layer. According to the characteristics of CES, The data acquisition and transmission can adopt two modes. The cooling and heating source systems usually have themselves monitoring platforms for normal operation, which can be integrated into the monitoring platform of CES directly and the data communication takes wired network. As the metering instruments of different buildings need to be installed on different locations of smart communities with large dispersion, the mode of data acquisition and transmission adopts smart meters + data acquisition devices. A data acquisition device usually connects with multiple smart meters that may take a wired or wireless network transmission. Fig. 1 is the architecture of CES. According to the acquisition data, the field instruments include single-phase electronic energy meter, three-phase electronic energy meter, three-phase electrical parameter acquisition modules, heat meters, cool-heat meters, water meters, gas meters and so on. In order to unify the data communication, the instruments selected adopt RS-485 communication interface and MODBUS-RTU protocol. The LCDAUE -800D embedded data acquisition devices produced by Shandong Lichuang are selected as the data acquisition

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devices, which are responsible for collecting the real-time data of electricity, cool-heat energy, natural gas of CES. The data acquisition devices connected with field instruments directly by RS-485 interfaces and connected with the data centers by Ethernet interfaces. The LCDAUE-800D device has an Ethernet interface, four RS485 interface, one RS232 interface. The RS485 serial port supports Modbus-RTU protocol, multi-function power meter communication protocol DL/T 645-1997 and household meters data transmission technology CJ/T 188-2004.

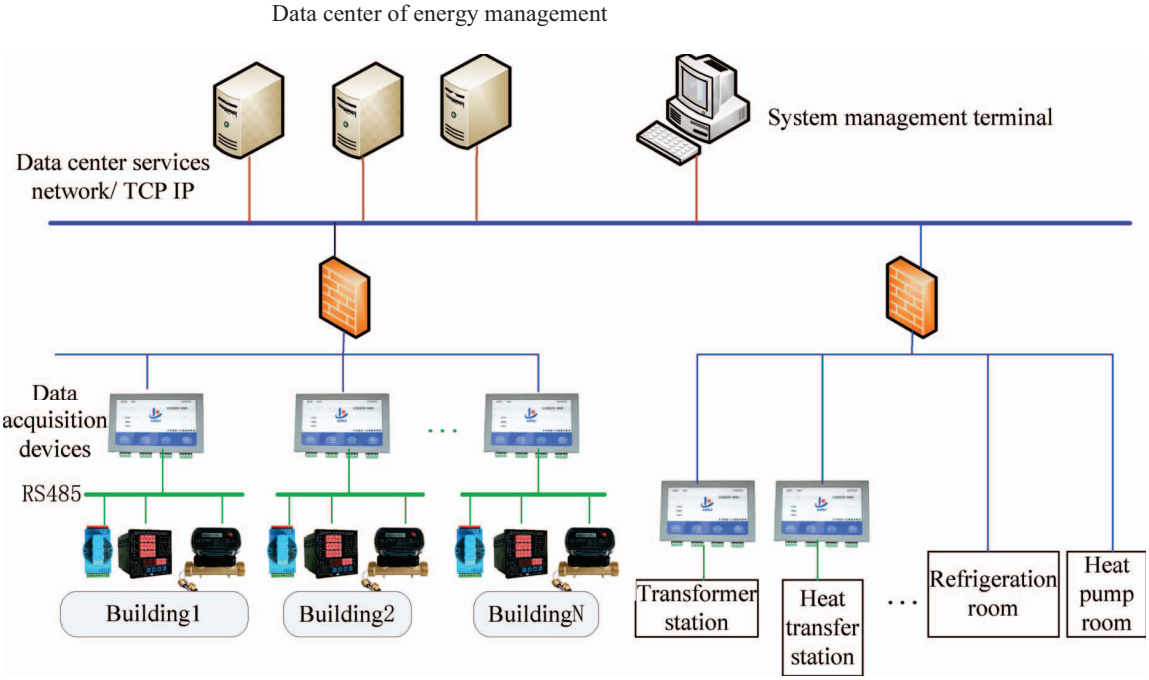

Fig 1. architecture of CES

3 DATA COMMUNICATION

3.1 Data Communication between Data Acquisition Devices and Field Instruments

The data communication between field instruments and data acquisition devices adopts RS-485 interface and Modbus communication protocol, which is a master-slave structure and half-duplex mode. The data acquisition devices are hosts, and the field instruments are slaves. The data acquisition devices communicate with field instruments according to data center commands or actively sending a request command to the field instruments. The following is the serial communication program between data acquisition devices and field instruments.

```
Imports System.Text
Imports System.IO.Ports
Public Class Form1
    Dim cmd_status As Boolean
Dim cmd_num As Integer
Private Delegate Sub dele()
Private Sub Form1_load(ByVal sender As system.Object, ByVale As system.EventArs) Handles MyBase.Load
Control.ChechForIllegalCrossThreadCalls=False
   For  Each sp As String In SerialPort.GetPortNames
     cmdCOM.Items.Add(sp)
 Next
   cmdCOM.Sorted=True
   cmdCOM.SelectedIndex=0
cmd_status=True
cmd_num=0
Try
    With SerialPort1
        PortName=cmdCOM.SelectedItem.ToString
        BaudRate=9600
Parity=IO.Ports.Parity.None
DataBits=8
StopBits=IO.Ports.StopBits.One
Encoding=Encoding.Unicode
End With
SerialPort1.Open()
Catch ex As Exception
Msgbox(ex.ToString)
End Try
```

3.2 Data Communication between Data Acquisition Devices and Data Center

The data communication between data acquisition devices and data center adopts TCP / IP protocol. At first, the data acquisition device initiates a TCP connection with the data center, and the TCP connection will be maintained after building the connection. Then, the data acquisition device sends heart beat data packets to the data center and monitors the connection status at scheduled times. Once the connection is broken off, which will be re-established. The data center authenticates the data acquisition device after a TCP connection. When one field instrument occur faults, the data acquisition device will send fault information to

the data center. The data packets format of application layer adopts XML. Fig. 2 is the communication process between the data acquisition device and data center.

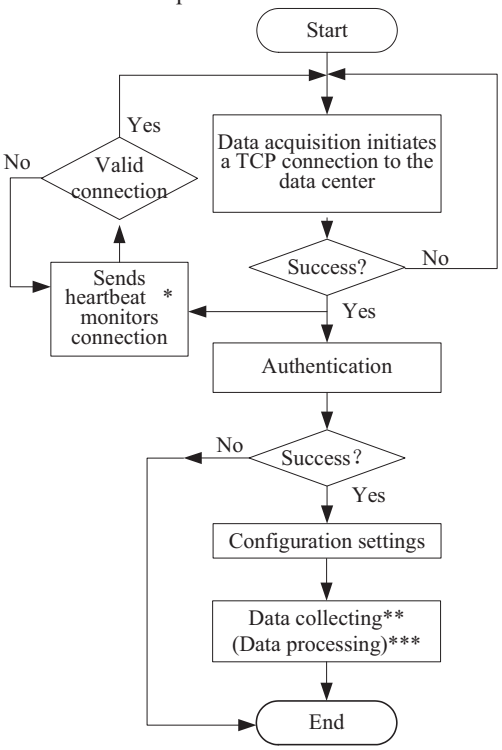

Fig 2. Communication between data acquisition device and data center

4 SOFTWARE PLATFORM OF DATA CENTER

Fig. 3 is the software system framework of data center, which is divided into three layers, data communication and processing layer, data display and analysis layer and information layer, respectively. The development of data center adopts Visual Studio2010, c # language and SQL Sever 2008 database.

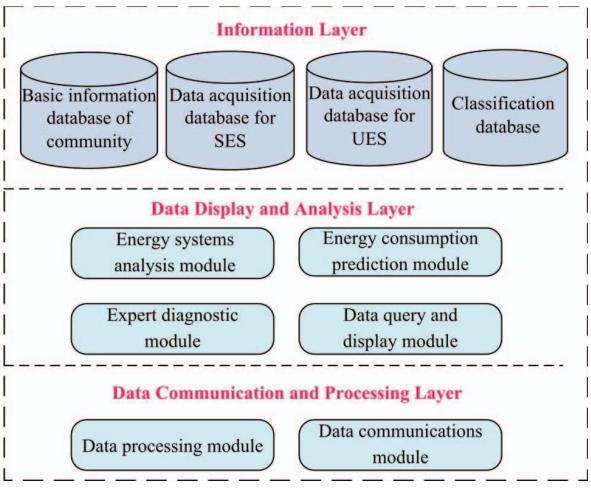

Fig 3. Software system framework of data center

4.1 Data Communication and Processing Layer

4.1.1 Data communication module

The data communication module is responsible for data communication and data acquisition. The data communication between data acquisition devices and data center adopts TCP/IP protocol. The data communication module transmits the data received to the data processing module.

4.1.2 Data processing module

The data processing module is responsible for calibrating and analyzing the data packets received from data acquisition module and standardizing the acquisition period. The model of energy using is built according to the instruments mounted in distribution branches. The sub-energy consumption data can be calculated according to the model of energy using. The original data and the processed data will be kept into the database.

4.2 Data Display and Analysis Layer

4.2.1 Energy systems analysis module

For the SES, the data of energy system are analyzed according to the data collected from transformer stations, heating stations, refrigeration plant, and etc. The data analysis includes load efficiency of the transformer, COP of heat pump (coefficient of performance), COP of refrigeration plant, imbalance ratio between hot and cold load of ground source heat pump. For the UES, the data analysis include total building energy consumption, total building electricity consumption, electricity consumption per unit area, electricity consumption of air conditioning per unit area, heat consumption per unit area, cooling consumption per unit area and etc. Fig. 4 is the data analysis of heat pump plant for Jigang community located in Jinan. The COP and EER of heat pump system can be derived from fig. 4. The COP dynamical curve is on the lower part of fig. 4.

4.2.2 Data query display module

The energy consumption data of SES and UES are analyzed according with time, items and regions. The users query the required data through multiple dimensions (time, region, type of construction, energy classification, statistical type, etc.). The energy consumption data will be displayed by static reports and dynamic charts. The data reports can be divided into daily reports, weekly reports, monthly reports and annual reports, which have relatively fixed format. The data charts reflect the numerical value, trend and distribution of the collected data and the statistical data, which can be divided into bar charts, pie charts and line diagrams.

4.2.3 Expert diagnostic module

The expert diagnostic module can analyze the operation of SES and the utilization of UES. It can find the potential points of energy saving by analyzing the devices energy consumption of SES and find the loopholes in management.

Further, the optimization scheme of system and reasonable suggests of equipment replaced will be proposed according with the load analysis of different equipments, for example, transformer, heat pump, air conditioner, etc. The devices operate at a reasonable load, which can improve the equipment utilization and reduce the extra energy consumption. Fig. 5 is the energy consumption diagnostic of shopping building for Jigang community.

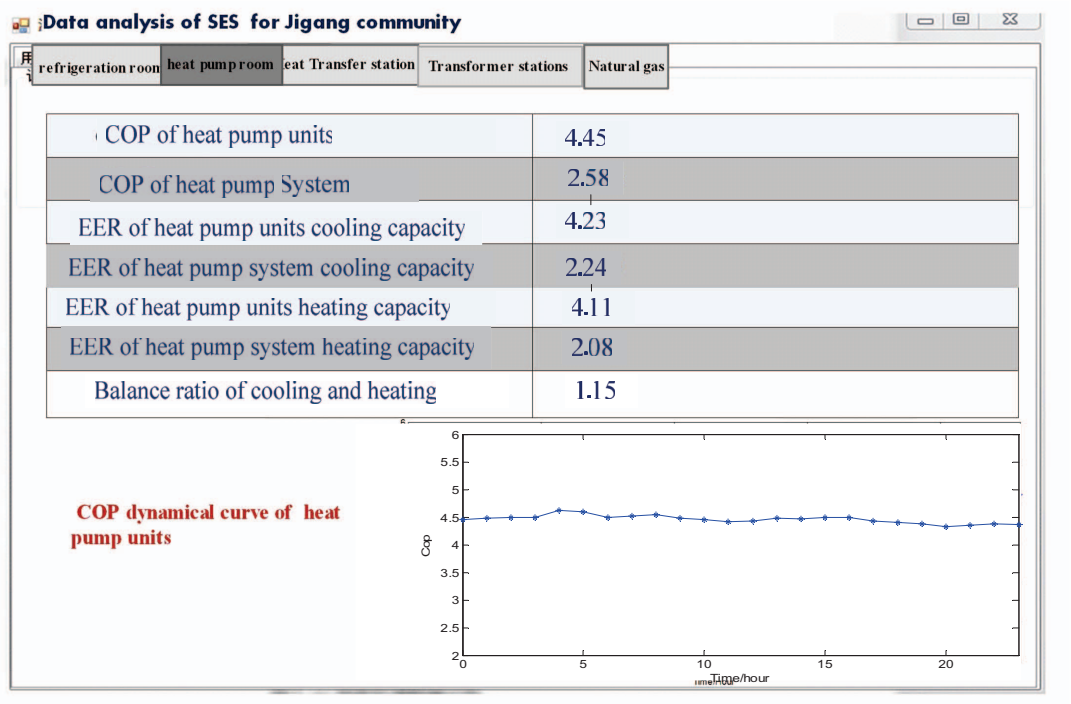

Fig 4. Data analysis module

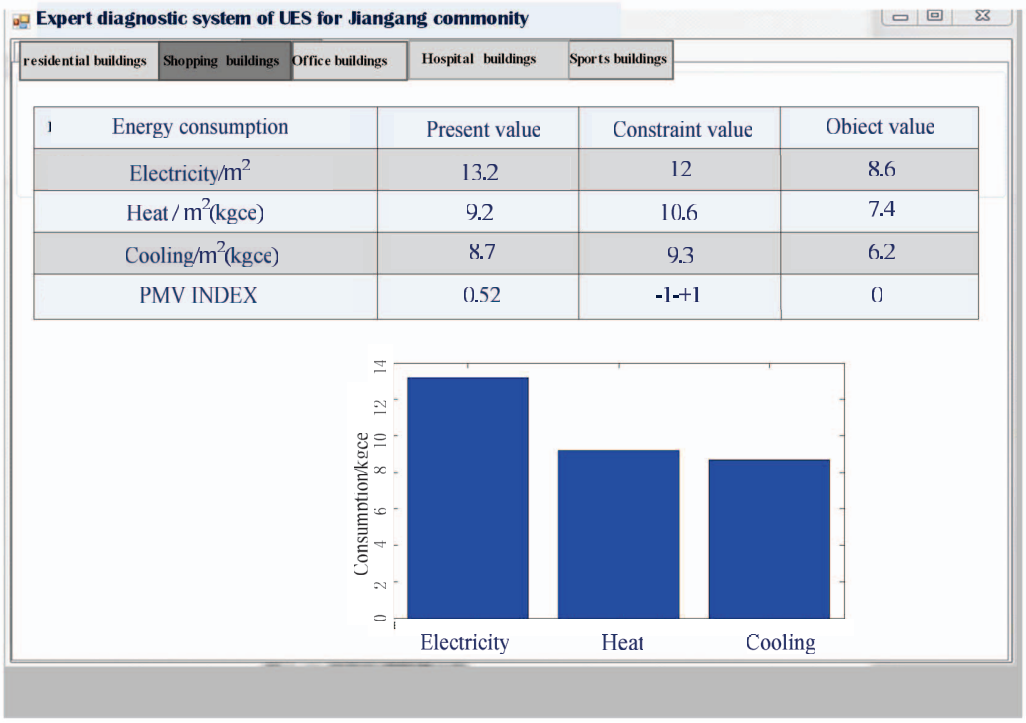

Fig 5. Expert diagnostic module

4.2.4 Energy consumption prediction module

The energy consumption of supply energy equipments and the energy utilization of different buildings are predicted based on artificial neural network methods according to the data collected. The prediction methods of energy consumption can refer to the previous research results of authors[7]. The energy consumption prediction model can further be used to optimize the energy systems running.

4.3 Information Layer

The information layer mainly includes basic information database, information acquisition database for SES, information acquisition database for UES and categorized database. The basic information database includes basic information of community, basic information of SES and basic information of UES. The information acquisition database for UES and SES mainly include field data of electricity sub-system, field data of heating sub-system, field data of cooling sub-system and the amount of natural gas, etc. The categorized database can be derived from energy data analysis module. Fig. 6 is the information structure of SES for Jigang community according with the actual situation.

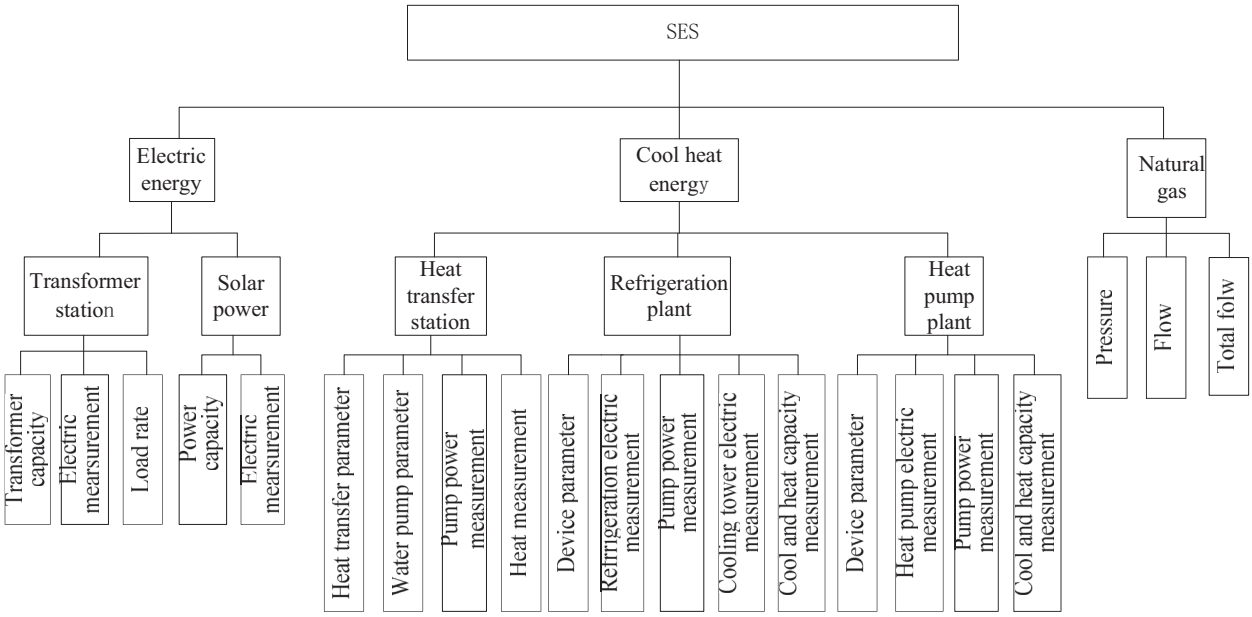

Fig 6. Information structure of SES for Jigang community

5 CONCLUSION

The energy management system for smart community is a flexible solution of data acquisition, data communication and data process for integrated management of supply energy and using energy. The information platform developed can monitor the SES and UES and evaluate the energy-saving of community. Furthermore, it can find out the power consumption problems and seek ways to reduce the building's power consumption with corresponding energy-saving renovation measures. It can provide the basis for optimal scheduling of energy system for smart community.

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