1. System Architecture

The developed web-based energy management system consists of two parts: hardware and software. Fig. 1 shows the hardware architecture where two modules (TCPIR-51 and IR-485) are deployed in three different networks (direct Ethernet, Ethernet with Network Address Transfer, and RS485 with RS485-232/TCP-IP converter) to demonstrate the flexibility of the system. These two modules can transmit infrared (IR) signals, based on the command from the software in the energy management center on a PC, to control the air conditioners (ACs) in classrooms. The software processes the data measured by the hardware and then sends commands to TCPIR-51/IR-485 based on the energy management rules. Figs. 2-4 depict the developed software GUIs: demand control GUI, total load profile GUI, and historical data inquiring GUI. The purposes of this system are to reduce the penalty bill on demand contract violations and to save energy consumption.

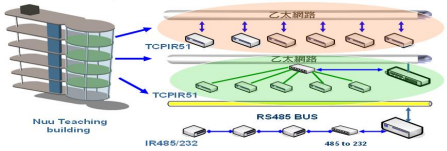

Fig. 1 Hardware architecture

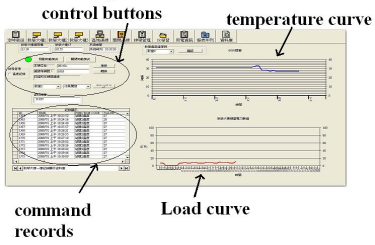

Fig. 2 Demand control GUI

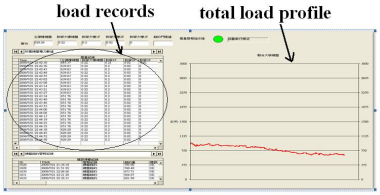

Fig. 3 Toal load profile

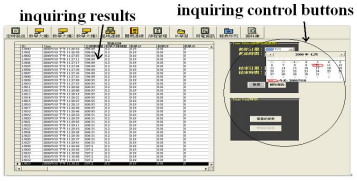

Fig. 4 Historical data inquiring

2. Features of the System

With the abilities of collecting power consumption data from the power meter, of controlling the developed TCP-IP/IR-485 modules through the internet, and of applying available demand control rules, the developed program can effectively regulate the aggregated window/split ACs to lower the peak demand, therefore to decrease the penalty bill on demand contract violations, as well as to save the energy consumption. The program not only uses load demands but also collects the temperature readings from the classrooms as parameters for demand control. Fig. 5 illustrates the demand control strategy used in the developed program. The ACs are divided into three groups and each group is distributedly controlled. The demand control is realized by changing the operating mode of ACs from air conditioning to fanning while keeping the room temperature below 26℃. The students in the classrooms will not feel uncomfortable. The program uses IR signals as control media; therefore, the energy management system is non-invasive to the ACsð no need to alter the circuits of ACs.

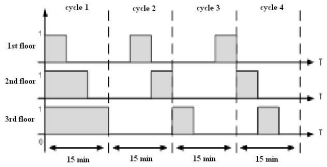

Fig. 5 Demand control strategy

3. Tools

(1) **Hardware:** TCPIR-51 is a web-based IR remote control with one Ethernet port and one RS-232 port. IR-485 is a simplified version of TCPIR-51 and only has one RS-485 communication port. Both can transmit/receive data to/from the remote energy management program via Internet. The IR transmitter circuit built in TCPIR-51/IR-485 can control the operation modes of ACs.

(2) Software: The program is coded using Visual Basic and is user-friendly. Several GUIs are developed (Figs. 2-4).

A. Demand control GUI: This GUI deals with the communication of distributed hardware modules, displays load/temperature curves and command records, and provides demand control buttons.

B. Total load profile GUI: This GUI shows the current total load data, total load curve, and load (demand) records.

C. Historical data inquiring GUI: This GUI provides the user to inquire historical daily load data for analysis and evaluation.

4. Results

Fig. 6 shows the total load variations of 56 ACs in 28 classrooms at the National United University, Taiwan, for two different scenarios: one with demand control and the other without demand control. Both were tested on the same weekday (Thursday). The peak demand is approximately decreased by 60 kW. This system can decrease the penalty bill on demand contract violation about NT$228,072 a year, the energy bill about NT$45,000 during the summer time, and the emission of carbon dioxide about 2,166 (Kg CO_2) per month. This is promising for commercializing the developed system.

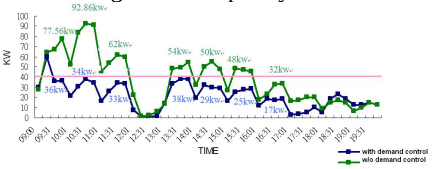

Fig. 6 Total load variations for two scenarios