Influence of Different Cooling and Heating Source on Office Building Energy Consumption in Chengdu City

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ABSTRACT
Combined with the climate features and utilized energy conditions in Chengdu city, three kinds of cooling and heating source were selected and their influence on office building energy consumption was analyzed with eQUEST. The results show that ground source heat pump(GSHP) units is suitable for office building in Chengdu, and it can can save 8% electric power per square meter than Air-cooled heat pump units and can save 26.67% electric power per square meter than Centrifugal-chiller plus gas boiler. Ground source heat pump(GSHP) units should take priority of selection for office building.

KEYWORDS
Office building, Energy consumption simulation, Cooling and heating source, eQUEST

INTRODUCTION

Energy consumption issue has been becoming increasingly obvious and attracting attention from all circles[1]. Sustainable development with low-carbon economy is widely accepted in the world. At present, building energy consumption is almost 1/3 of China social total energy consumption[2-3], which has become one of three "big energy consumers", including industrial energy consumption and traffic energy consumption. Moreover, improvement of working condition and living comfort demands makes building energy consumption be increasing continuously.

The percentage of air conditioning system to public building energy consumption is 50%~60%, so energy conservation of air conditioning system has a big significance to building energy conservation[4-6].

Air conditioning energy consumption of different cooling and heating sources is dfferent in the same climatic conditions. This paper simulated energy consumption of office building with different form of cooling and heating sources in Chengdu city, the characteristics of

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which were analyzed, the suitable cooling and heating source was chosen for Chengdu office building based on energy conservation.

BUILDING OUTLINE and HEAT and COLD SOURCE SCHEMES

One office building has 6 stories with office, meeting room, parlour, hall and so on. The first floor is main for large space area such as hall and business acceptance area with 4.8m of height; The others are offices, meeting rooms and equipment rooms with 3.3m of height. Total building area is 4870 m^2.

In view of the actual situation in Chengdu, three main cooling and heating source schemes were selected as energy consumption analysis and comparative objects. PR&SP is shown in Table 1. Terminal units all adopt fan coil + dedicated outdoor air systems (CDOAS) .

Table 1. *Scheme of air conditioning system*

Name	Cooling and heating source	Terminal unites	Summer coefficient	Winder coefficient
Scheme 1	Centrifugal chiller+gas boiler	Fan coil+CDOAS	8.200	0.806
Scheme 2	Air source heat pump	Fan coil+CDOAS	8.200	2.900
Scheme 3	Ground source heat pump(GSHP)	Fan coil+CDOAS	10.500	3.800

BUILDING MODEL and SIMULATION CONDITIONS[7-8]

eQUEST is an energy consumption software, explored by LGNL, Hirsch and his partner ,with the financing aid of U.S.Department of Energy and Electric Power Research Institute. The computing core of this software is the advanced version of DOE-2-DOE2-2. eQUEST not only absorbs the merits of DOE-2, but has some other new function which making the progress of simulation much easier and the formation of results more obvious.

The modeling of eQUEST consists two stage, Wizard Data Edit and Detailed Date Edit. There are two modes in the Wizard Data Edit setting: Bldgshell Components and Air-side System types. The settings of Bldgshell Components include building category of every floor, inside layout of every floor, floor height, orientation, roof structure, floor/ material of glass curtain wall, building working hour, operating area, energy consumption of electric equipment and so on. The setting of Detailed Date Edit consists Project&Site Building Shell， Internal Loads， Water-Side HVAC and Air-Side HVAC, including the settings of building working hour in every day, month and year, meteorological parameter, building envelope and so on . Building model as shown in Figure 1.

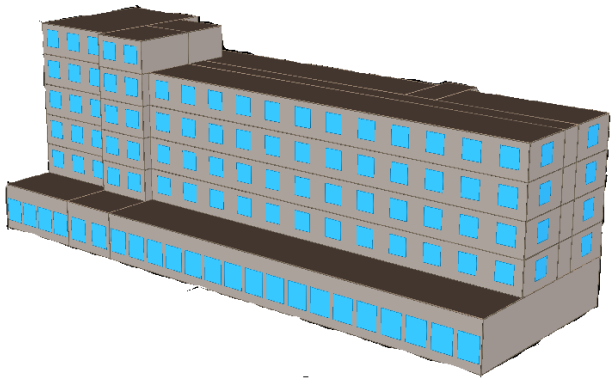

Figure 1 *Building model*

Table 2 and Table 3 show the calculation parameters, including materials of building envelope and their thermal parameter, indoor load and so on.

Table 2 *Main parameters of building envelope*

Building envelope	Structure and thickness	Heat transfer coefficient W/（m2 • K）
exterior wall	20mm cement grout 370mmShale sintering porous load-bearing brick 20mm cement grout	1.22
interior wall	20mm cement grout 240mm brick wall 20mm painting inside	1.974
Roof	35mm concrete 20mmcement grout 5mmvapo(u)r barrier 200mmcement and expanding pearlite 350 20mmcement grout 5mmwaterproofing membrane 5mmSand gravel outside surface	0.49
Floor	7mmfive-layer plywood 80mm reinforced concrete (RC) 25mmcement grout 25mm marble	0.508
Exterior windows	PVC frame Low-E hollow glass 6+12A+6	2.444

outside door	Energy-saving door	3.02

Table 3 *Indoor simulation conditions*

Items	Office	Leadership office	Meeting room	Passage	Others
Lighting load/（W m^{-2}）	11	18	11	5	11
Equipment load/（W m^{-2}）	20	13	5	0	5
Person-density/（m^2 $person^{-1}$）	4	8	2.5	25	10

According to the model, meteorological parameter is adopted to make the simulation. The meteorological parameter is the BIN parameter of DOE conveyed from EPW meteorological parameter. EnergPlus gives all meteorological parameter of main cities in China. Based on the air conditioning heating/cooling operation rule in summer and winter in Chengdu, make sure that cooling season is from 20th June to 20th September, heating season is from 10th December to 10th February of next year. Air conditioning system does not work on national holidays and weekends. The workday is from Monday to Friday; Day running time is 8：00-17：00；Fan will work one hour before opening and after closing air conditioning system.

RESULT ANALYSIS of ENERGY CONSUMPTION SIMULATION

The electric power consumption and gas used for heating within a time-span of mouths of three schemes is shown in Figure 2 ~Figure 3. Energy consumption of lighting, fan, and equipment has a small change during the whole year , but the energy consumption of heating and air conditioning have a significant change with the change of mouth. The former has a close relative with the quitting time; and the later will change with outdoor temperature.

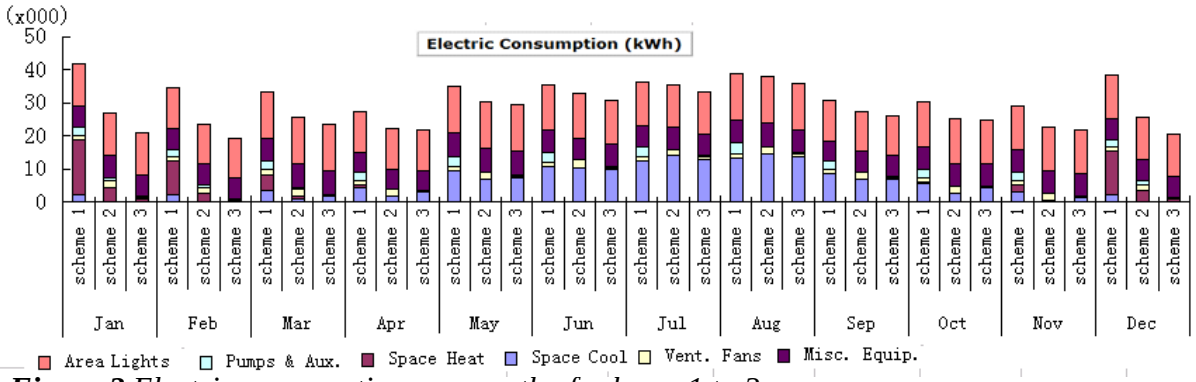

Figure 2 *Electric consumption per mouth of scheme 1 to 3*

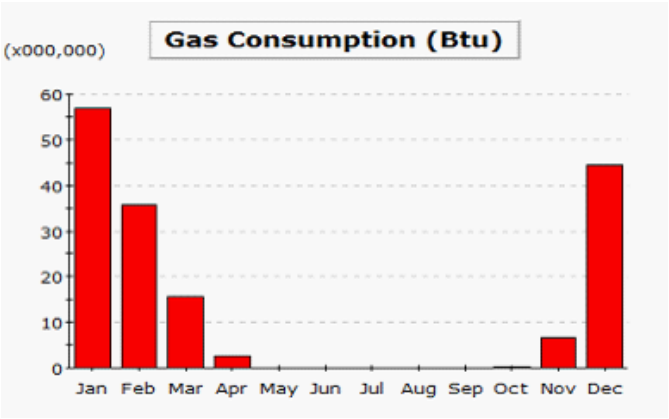

Figure 3 *Gas consumption per mouth of scheme 1*

Figure 4 shows the comparison of electric consumption of the three schemes per month during whole year. The electric consumption of scheme 1 is converted from gas consumption to electric consumption. The Centrifugal chiller+gas boiler cost the most electric energy, followed by Air-cooled heat pump units and Ground source heat pump(GSHP) units.The peak of electric consumption of three schemes all appear in August, heating energy consumption peak appears in January, this is because heating and air conditioning energy consumption changes with outdoor temperature. Calculation suggests the electric consumption of three scheme in whole year is 18.39MWh, 338.31MWh and 309.87MWh; and per square meter costs electric energy 86.75kWh/m^2, 69.47kWh/m^2, 63.62kWh/m^2. By comparison, Ground source heat pump(GSHP) units can save 8% electric power per square meter than Air-cooled heat pump units and 26.67% electric power per square meter than Centrifugal chiller+gas boiler. This is mainly with the Ground source heat pump(GSHP), heating boiler can only convert 70%~90% fuel energy into heat； and compared with Air-cooled heat pump, Ground source heat pump(GSHP) heat source temperature throughout the year is relatively stable, generally 10~25℃, and the refrigeration heating coefficient is higher than Air-cooled heat pump , so Ground source heat pump(GSHP) is more energy saving.

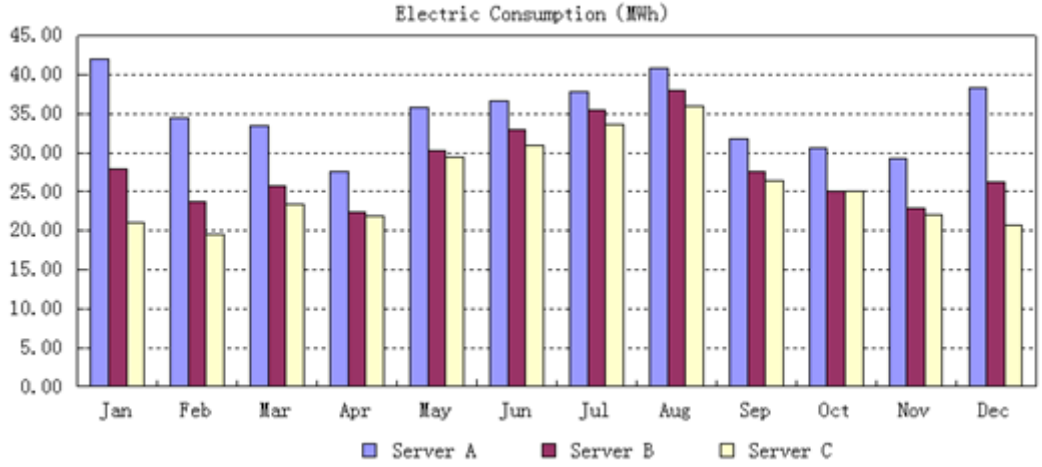

Figure 4 *Comparison of electric consumption per mouth of three scheme*

CONCLUSION

This study analyzed the energy consumption features of three air conditioning cold and heat source scheme of an office building in Chengdu with the software eQUEST and gets below conclusions.

(1)Ground source heat pump(GSHP) units is suitable for office building in Chengdu, and it can can save 8% electric power per square meter than Air-cooled heat pump units and can save 26.67% electric power per square meter than Centrifugal chiller+gas boiler. Ground source heat pump(GSHP) units should take priority of selection for office building.

(2)The peak energy consumption of office building appears in August, and the peak heating consumption appears in January. This is relative with the climate of Chengdu.

(3)The energy consumption of lighting, fan, pump and equipment dones not change a lot in the whole year, bur the energy consumption of air conditioning changes a lot with months.

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