

The Development Direction of Saving Energy for Chinese Architecture and the Utilization of Renewable Energy

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Abstract: The energy used for architecture of China has occupied 25 percent of the total value of whole country. With the rapid development of urban in China, it is estimated that the ratio of urban will come to about 60 percent in 2020, at that time the energy used for architecture would increase to a new level. In order to achieve the sustainable supply of energy and meet the demand of country development, the renewable energy and the techniques of saving energy should be applied in the field of architecture. The renewable energy is geothermal energy and solar energy etc. The techniques of saving energy are defined as techniques being used to make use of waste heat and other techniques of saving energy, such as the technique of strengthening heat preservation of outer wall, heat insulation and heating of windows, the heating with floor radiation and air conditioning techniques and saving energy for living hot water system etc.

Keywords: renewable energy, solar energy, geothermal energy, floor heating with low temperature radiation.

1. INTRODUCTION

In 2003 the provision crisis of coal and power occurred in China and this trend continues to expand in 2004. Switches had been turned off to limit the power provision and temperature of air conditioner in hotels had been limited in most areas all over the country. Additionally with the rise of oil price, new challenge of energy provision takes place in china. The energy used for architecture is a large user in the energy provision of all county, at present it occupies about one quarter of all the energy sources^[1]. Saving energy used in architecture has positive significance for the Chinese energy provision. China plans that in 2020 the wastage of primary energy would get to 27 hundred million tons normal coal. However it is estimated that the amount of primary energy provision is only 20 hundred million tons coal. The shortage of energy provision is huge and can be solved only through saving energy^[2]. Saving energy of architecture in china has two developing direction: one is using the renewable energy, such as solar energy, geothermal heat, wind energy, air energy, biology energy and other waster heat being used etc. The other is using systems with better performance of heat preservation and saving energy. At present our goal of saving energy is to reach 65 percent compared to that of 1980s. The heat preservation of building mostly adopt techniques of heat preservation for outer wall, windows with limitation of window-wall ratio and glass heat transfer system. The systems providing heat and cooling adopts the heating with floor radiation and air conditioning techniques i.e. the techniques of heating with low temperature and the techniques of refrigeration with high temperature. Heat measure can be used to limit the use of heat. The techniques of

storage heat and cooling can also be used to make the entire system of energy provision reasonable.

2. THE STATUS QUO OF ENERGY IN CHINA

Since primitive learned to use fire, the society of human approximately experienced three energy period i.e. firewood period, coal period and oil period. In the course of this period there happened two important changes of energy consumption structure. The first change began with 1760s during the English industrial revolution, the emergence of steam engine symbolizes the human beings have learned how to change the heat energy into mechanical energy, accordingly the dominating energy becomes oil from firewood. The second change happened at 1920s, the dominant status of energy consumption was occupied by oil but not coal. To 1967, the production of crude oil got to 18 hundred million tons, in the proportion of primary energy consumption structure the crude oil(40.4%) exceeded that of the coal(38.8%) ,which indicates that human society has come into oil period. Since the time entered 1990s, with the environment problems standing out day by day ,the environment consciousness of people has been wakened and strengthened, the proportion of primary energy structure for natural gas had been moved up year after year, till 1996 the proportion of natural gas had occupied 23.2 percent. It is predicted that 21st century would be natural gas period. The gross of energy consumption was about 13 hundred million tons normal coal, thereinto coal was 9.07 hundred million tons normal coal and occupied 69.9 percent ; petroleum was 3.24 hundred million tons normal coal and occupied 25 percent; natural gas and primary power was 0.36 and 0.29 hundred million tons normal coal respectively, natural gas and primary power occupied 2.8 percent and 2.3 percent respectively;

therefore the Chinese energy structure still gave priority to coal.

The coal being energy can produce coal tar, carbon dioxide and sulfur dioxide which can cause the atmosphere pollution. Carbon dioxide is forbidden by the international agreement of Kyoto for the contribution to greenhouse effect and the desulfurizing technics has to be adopted because sulfur dioxide can form acid rain, which add the cost of the coal as energy. Therefore our country is seeking some new technics represented by gas engineering. At present large-scale gas engineering has been build up to produce cleaner energy of man-made natural gas.

Till 2020 the goal of energy in China is: the demand of primary energy is less than 25 hundred million tons normal coal, the amount of saving energy is expected to reach 8 hundred million tons normal coal; the proportion of coal consumption is controlled at about 60 percent, the utilization of renewable energy come to 5.25 hundred million tons normal coal (thereinto power generated by renewable energy come to 1 hundred million kilowatt); the dependence extent of petroleum is controlled at about 60 percent; the cutting ratio of primary contamination is from 45 percent to 60 percent.

China has extended the application of renewable energy technology energetically^[2]. Renewable energy mainly refers to solar power, wind power, biology power and geothermal energy etc^[2]. The concept of "distributing energy" has been put forward in the national policy, i.e. the general utilizing system for energy to be distributed at the end of users, the primary energy is given priority to gas fuel, renewable energy is a complement of that, the energy that can be used should be utilized; the secondary energy is given priority to the production of heat, electricity and cooling at the end of users, other central energy supplying system is complement of that, therefore the energy step utilization can be realized to meet more demand of users and be complemented by using central energy supplying system^[3].

3. THE ENERGY USED IN ARCHITECTURE OF CHINA

Chinese economy scale ranks No.7 in the world, but the petroleum consumption of China is only inferior to that of America and Japan and ranks No.3 in the world. Energy used in architecture of developed countries occupies from 30 percent to 40 percent of their total energy consumption^[4]. Energy used for architecture of China occupies about 25 percent of total energy consumption of all country because there are a lot of population in the country. With the rapid development of urban construction, the energy used for architecture show a unceasing increscent trend. About 75 percent energy of human is used in transportation and architecture, among this 75 percent energy 1/3 energy of that is used in the heating, air conditioning, hot water supply, lighting and elevator of the building.....now the building has become a big user of energy consumption in our country. In 1998 the total gross of energy consumption of Chinese building already came to 4.3 hundred million tons normal coal. Till 2020 the amount of Chinese energy consumption would reach 2.6-3.3 times of that of 1998.

The population statistical data after China founded 50 years is shown in fig. 1. According to the experience of international development the population of urban would enter into the taking-Off period when the ratio of urban reached 80 percent, when the ratio of urban reached from 30 percent to 75 percent the population is in a developing period with high speed, when the ratio of urban exceeded 75 percent the speed of population moving began to slow down. The Chinese urban development proved the rule of international development. The ratio of urban population in china was 30.48 percent and entered into the developing period with high speed since 1996, to 2003 the ratio of urban population was 40.53 percent, the average increase of urban population per annum is 1.44 percent. In 1998 Chinese population was 12.47 hundred million, the amount of urban population occupied 33.35 percent of total population and was 4.16 hundred million. In 2000 Chinese population was 12.67 hundred million, the amount of urban population occupied 36.22 percent of total population and was 4.37 hundred million, the amount of urban population occupied 33.35 percent of total population and was 4.16 hundred million.. In 2003 Chinese population was 12.92 hundred million, the amount of urban population occupied 40.53 percent of total population and was 5.02 hundred million. In 2020 the amount of Chinese planning population will reach from 16 to 17 hundred million, the amount of urban population will occupy 55 percent above of total population and is from 8.8 to 9.35 hundred million. If in the terms of the present increase ratio of urban population and the total number of planning population, the amount of urban population would occupy 65 percent of total population and is from 10.4 to 11 hundred million which is about twice of that of the present population.

The statistical source of construction energy is mainly urban population, to 2020 the urban population will increase as twice as present, the construction energy would increase at least twice. Since entered into 21st century Chinese government has felt the pressure of energy provision and energy crisis. In 2003 there happened the provision crisis of coal, power, oil and natural gas. In order to achieve the sustainable development and the sustainable energy provision, renewable energy should be utilized more and more^[5].

To save the energy consumption of construction Chinese government has already taken some measures, for instance, On July 1st 2004 the government of Beijing city announced the local executive criterion of "the design criterion for living building saving energy" DBJ01-602-2004, which regulates that all of the new buildings should save 65 percent energy on the basis of the basic energy consumption level of heating for universal living building design^[5,6]. The heat load guideline of heating design is not suitable to exceed 32 W/m². In 2003 energy research institute of Chinese law correction committee and construction department make collaboration with the World Bank to extend the use of hot water system and heating system with solar energy. The agricultural department has already extended the use of firedamp system by using human

excrement which can provide the energy of making meal and supplying hot water. Some places have begun to extend the use of geothermal energy and the use of waste water and waste heat. All examples listed above can symbolize Chinese government has done a great deal work for the utilization and sustainable development of construction energy.

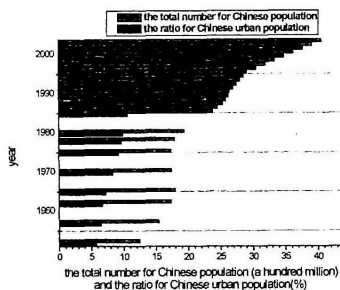


Figure1: the ratio for Chinese urban population with the increase of Chinese population

4.THE UTILIZATION OF SOLAR ENERGY

The energy that human must depend on all comes from the earth. However solar energy has been used by human for several decades, the utilization of solar energy is mainly solar batteries and solar hot water system. The radiation power of sun is 160×10^{21} kW, there is only minimum of that to reach the earth. The solar radiation power that aerosphere of earth accepts is 1.75×10^{17} kW, among that there is 30 percent energy reflecting back to aerospace, 47 percent energy being absorbed by aerosphere and the surface of earth, 23 percent energy reaching earth to become the drive of wind ,air and water, then forms climate and hydrography, there is only 0.02 percent of energy accepted by earth can be absorbed by the plant to finish photosynthesis and to produce biology energy.

The advantage of solar energy is abound in storage, universal, unpolluted, economic. Solar energy is inexhaustible regardless of how human use it. The first disadvantage is dispersive, low density of energy flow; the second disadvantage is discontinuous and unstable, with the difference of climate, season, day and night the solar energy would accordingly vary a lot; the third advantage is: the using efficiency of equipment is low, the cost is high relatively. In conclusion there are capacious spaces for solar energy to develop, the utilization of solar energy for construction in China is mainly the solar energy hot water system. There are some kitchen rang using solar energy in high land region, but the number is not much.

American solar energy design association began to develop new solar energy-saving dwelling house in 1980s. This kind building doesn't adopt the method of installing some bulky equipment to collect solar energy but adopt the method of embedding the semiconductor which can change sunlight into power energy into wall and roof. 20 years before, the founder

of this association Steven.Armstrong first advocated this kind design thought of "solar energy and building is integrative" which could not be implemented just because the price of photonic material was too high. However the solar hot water system can be widely used because the price of this system is inexpensive.

At present the building associations of Europe, Australia and England provide a special type construction which has streamline roofs, multilayer glass windows and is equipped with water supply system and circular water system. The solar water heater for 28.4 ten thousand square meters had been installed in German, solar energy could satisfy 70 percent the need for hot water all-year, in summer 100 percent hot water in family could be supplied by solar energy.

Solar energy is abound in China^[2], the average radiation of the sun of one year in China is 5.9×10^6 kJ/(m².a). There are 2/3 areas of China where the irradiation time of the sun in one year is above 2000 hours, the radiation of that is higher than average. Especially in most part of Qingzang altiplate the radiation of the sun of one year exceeds 7.2×10^6 kJ/(m².a), the irradiation time of the sun exceeds 3000 hours. So Qingzang altiplate is one of the areas of high value for developing in the world . The distribution of solar energy in China is shown in table1, it is estimated the radiation energy of the sun for one year in China 5.7×10^{22} J is equal to 1.9×10^{12} tons normal coal.

Table1 the table for Chinese solar source distribution

area	The hours for sunlight every year/h	The total number for solar radiation every year/ 10^6 kJ/(m ² .a)
The north of Ningxia and Gansu, the southeast of Xinjiang, the west of Qinghai and Xizang	2800-3300	6. 7
The north of Hebei and Shanxi, the south of Interia Mongolia, Ningxia and Xinjiang, the middle of Gansu, the east of Qinghai and the southeast of Xizang	3000-3200	5. 4-6. 7
The southeast of Shandong, Henan, Hebei and Shanxi, the north of Xinjiang, Jilin, Liaoning, Yunnan and Shanxi, the southeast of Gansu, the south of Guangdong and Fujian, the north of Jiangsu and Anhui, the area of Beijing	2200-3000	4. 2-5. 4
Hubei, Hunan, Jiangxi, Zhejiang, Guangxi Heilongjiang and the north of Guangdong, the south of Shanxi, Jiangsu and Anhui	1400-2200	4. 2

Our country has made certain base in the using solar energy since 1970s. There are solar kitchen rang, solar water heater, solar energy house and solar desiccator etc. By 1995 China had widely used solar water heater for 400×10^4 square meters, solar kitchen rang 14000 pieces, passive solar energy house for 650×10^4 square meters, solar greenhouse for agriculture 27×10^4 square meters. The solar batteries having been used all over the country got to 6×10^7 kW. Four solar energy power plant (10-25kW) had been built to solve the problem of using electricity for people in 4 counties with no electricity^[7,8].

The price of solar water heater has dropped down to the degree to widespread. China is the most widely used for solar water heater system in the world. However, at present the solar water heater has been more used in small town and in the country than in large city. The reasons are as follows: The products of solar water heater are single and only consist of plate heat collector with cover plate, vacuum tube heat collector and plate heat collector without cover plate, their forms are all plate, this solar water heater only can be installed on the roof, it only can be used as subsidiary heat source because the area of roof is small and it is unstable and intermittent. Thus it usually results in designing system more complicated and seldom be used by public construction, but it has been used many projects, for examples: Yuebei hospital in Shaoguan Guangdong province, a hotel in Sanya city, a living district in Hangzhou city, the solar energy hot water system has been used as subsidiary heat source in these construction. At present the utilization of solar energy all over the country has the disadvantages of leaking water because of icing and sealed rubber cushion not resisting aging, for example, in Tibet the longevity of rubber cushion is about two years, these all limit the use of solar energy. Now some of these problems have been solved such as prevention for icing etc.

Now China is doing the research of standardization and series for solar water heater, which demands the building being composed of building block and system reasonable and can meet the need of connecting duct of water and providing water for the system. It can be predicted that the solar energy hot water system would be widely used in China in near future.

5. THE UTILIZATION OF GEOTHERMAL ENERGY

The inner of the earth is very hot and the temperature for the centre of the earth is about 4000°C , heat energy flow into the ground continuously and is radiated from the ground to the sky. The average heat energy of this surface is $8.2 \times 10^{-5} \text{ W/m}^2$, if the surface area of the earth is $5.1 \times 10^{14} \text{ m}^2$, then this heat loss is about $4.2 \times 10^9 \text{ Mw}$, it can be seen that this heat loss is huge. The human should effectively use this kind of renewable natural resource, usually it can be used in generating electricity with geothermal energy, heating and air conditioning with geothermal energy and living hot water system. In the world every country all make the utilization of geothermal heat, in some areas of Us the geothermal energy will generate electricity of 1300MW which is enough to meet the

need of using electricity in family for 1,300,000 person for California. It is estimated that 80000Mw geothermal energy can be obtained to generate electricity from the volcano system of developing country in the world, the potential geothermal energy of Indonesia is 19000Mw. The size of power plant with geothermal energy is from 300kw to 55Mw. The direct use of geothermal energy in the world is 9000Mw above. In Ireland there are nearly all the families and buildings using geothermal heat. Several cities in Us and New Zealand also use the geothermal heat for heating. Many countries use geothermal heat to heat the green house. Geothermal energy would provide 25%~50% the needed power and heat in the world.

The temperature of geothermal water usually has been divided into three grade, the temperature of low temperature water is lower than 90°C , the temperature of moderate temperature water is ranged from 90°C to 150°C , the temperature of high temperature water is higher than 150°C . The heat source for moderate temperature and high temperature usually can be used to generate electricity, the heat source for low temperature can be used directly, for example, industrial process, heat supply for regions, heating up the green house, food dryness and aquiculture etc. In China geothermal heat has convective geothermal heat and conductive geothermal heat. The regions for convective geothermal heat has been formed mainly because the collision between the Indian continent block and the Asia-Europe continent block and the collision between the Asia-Europe continent block and Philippine seabed block, which has formed the regions where geothermal heat activities isn't normal and the activities of geological structure is active, such as south of Tibet, west of Yunnan and east of Taiwan. The distributing of the regions for conductive geothermal heat is in 48 basin with different types in China, its water temperature is usually blow 90°C in 3000 meters deep, there are a few regions where the water temperature is higher than 90°C .

By 1998 there were 5 geothermal heat power plant in China, the total performance for generating electricity is 29Mw, there are 25Mw electricity being generated in Yangbajing Tibet^[7,8]. There were 1245 places using living hot water by geothermal heat. The geothermal heat used in agriculture and industry amount to 5000000 tons normal coal. The geothermal energy used for living hot water occupies 32.46 percent, the geothermal energy used for generating electricity occupies 13.77 percent. Since entered into 21st century China not only has developed generating electricity and supplying living hot water by geothermal heat, but also has developed the heating system and air conditioning system by using geothermal heat.

At present China has extended the use of geothermal water-source heat pump and geothermal ground-source heat pump, which can supply cooling in summer and supply heat in winter by using geothermal heat, by this means it can be achieve the enough energy provision by itself. On April 1st 2004 China implemented Chinese national standard of "the design criterion of heating, ventilation and air

conditioning" GB50019-2003 which is defined the design parameter and design method of water-source heat pump and ground-source heat pump, this symbolizes that the utilization of geothermal heat has been entered into a new era in China.

Water-source heat pump has been firstly used in China, but because the backwater possibly can cause pollution to the underground water and forming furring in the inner part of the system, those disadvantages help us to realize the water-source heat pump again. The utilization of ground-source heat pump is later than that of water-source heat pump, but is limited in use in centre part of the city because it needs a lot of long holes and a lot of areas. The hotel in some regions in China provides the customers with hot water of thermal spring to have a bathe and has accumulated a lot of experiences, we can summarize it and extend the use of it. At the same time we should consider the circulation of system, heating up the circular water or discharging the water to underground to guarantee the stabilization of hot water temperature. If the quality of geothermal water can not meet the need of the water quality criterion, we can take some water-cleaning measures or use the method of heat exchange to use geothermal energy. The techniques of providing living hot water with thermal spring is very successful and should be extended to use to reach the goal of saving energy.

In conclusion, as far as the utilization of geothermal heat is concerned, China has acquired some experience and will positively extend the use of geothermal living hot water system and heating and air conditioning system of geothermal ground-source heat pump.

6.THE UTILIZATION OF WASTE HEAT

In industrial construction waste heat has been utilized, such as the boiler using smoke given off from the blast furnace, it has not been widely used because the technical reason. However in civil construction waste heat utilization usually refers to the utilization of waste heat of cooling system for air conditioning, the utilization of waste heat of ventilation, the utilization of waste heat of polluted water etc. The utilization of waste heat of ventilation is usually by using heat exchanger with high efficiency, at present this techniques is very successful in our country, but this techniques is blocked to use because primary investment is very large. The utilization of waste heat of cooling system for air conditioning and the utilization of waste heat of polluted water usually adopt heat pump system, at present there is no relevant project, it is needed to develop the techniques and to degrade cost.

In summer a lot of heat in the house is exchanged to air conditioning system, finally the heat is given off to the air through cooling tower and cause heat pollution and hot-island effect. If these heat can be utilized to supply the heat energy to heat up the water of the living hot water system, which can realize the heat recycle of heat produced in condensation for air conditioning^[9]. In recent years with the development of water-source heat pump and ground-source heat pump, some mediums for high temperature of working fluid have been developed, for instance the highest temperature of outing water for

R22 is 55°C, but in recent days Us has developed a high temperature working fluid named HTR01, the highest temperature of outing water is 85°C, this working fluid is enough to meet the need of living hot water, at present this work fluid is reach the degree to begin to use. It is believed that the waste heat recycle for cooling system of air conditioning would be able to further develop. The other system is heat pump with water-loop air conditioning system, this system realizes the waste heat recycle by using water-loop to connect the water heat pump and air heat pump. This system can not be widely used because the cooling tower is close and the cost of that is high.

In conclusion the utilization of waste heat is at the beginning of research and development. At present the technique and equipment is not ripe and have a spacious space to develop, especially the utilization of waste heat of cooling system for air conditioning system and the utilization of waste heat of polluted water^[10].

7.THE SAVING ENERGY TECHNIQUES FOR ARCHITECTURE

The energy used for architecture is mainly used for heating, air conditioning, water supply, living hot water, lighting and power etc. Lighting uses energy-saving lamp, electricity uses in power use electromotor with high efficiency. This research paper mainly introduces the saving energy problem of heating, air conditioning and living hot water. In 1988 it is investigated that Beijing, Dalian, Shenyang, Changchun, Haerbin etc normal coal consumption of one year for heating in winter is 25.3kg/m²·a which is as triple as that of developed countries, it can be seen that the Chinese construction has a big space to develop^[9,10]. At present techniques of saving energy is embodied as follow.

In order to make the best of solar energy, windows can be used to guide the sunlight to enter into the house, or building collecting heat wall can storage the heat in the day and give off the heat in the night. In order to make the best of the heat in the building, for instance the heat of kitchen can exchange the heat with other heat, collecting waste heat can provide building with the heat to achieve the goal of saving energy. In order to degrade heat loss we should use heat preservation techniques of outer wall and limiting the window wall ratio, decreasing the heat transfer coefficient, degrading the heat transferred to the atmosphere, adopting heating technique with low temperature, decreasing the heat loss of network of duct, adopting the windows and doors with good sealed capability, the reasonable ventilation can prevent overmany cold air from increasing the energy consumption. Spreading the use of heat measure can save 20~30 percent energy according to the experience of using heat measure in Europe. As far as air conditioning system is concerned, it should use sunshade of window and heat preservation techniques of outer wall to limit the heat loss, it also can make use of air conditioning techniques with floor radiation, when the temperature of refrigerant water is below 20°C the heat loss of cooling medium can be decreased.

The heating techniques of floor radiation had been used at the beginning of 20 century in Europe

and Soviet Union. This techniques had also been used in our Great Hall. This techniques can not be widely used because the pipeline laying and pipeline design is not perfect. With the demand of saving energy, environment protection and the demand of comfort the techniques have made rapid progress since 1990s. At the same time the heating techniques of floor radiation can be fitted to low temperature water whose temperature can be about 40°C, which can create advantage for the utilization of geothermal heat, waste heat and solar energy. Therefore the heating techniques of floor radiation has make a striking progress in our country, only can the heating techniques of floor radiation make the low temperature heat source such as solar energy, geothermal heat and waste heat have a brilliant future. The heating techniques of floor radiation and air conditioning techniques have been used in Fengshang apartment Beijing and has made good effect, which makes a symbol that this techniques is very successful in China. At present the state criterion has clearly regulated the design parameters. Regulations for the heating techniques of floor radiation has been announced in Beijing to extend the use of this techniques. In conclusion the heating techniques of floor radiation and air conditioning techniques has been widely used as a saving energy technique and has a prosperous future.

The heat preservation of living hot water system usually adopt heat preservation material for pipe with good heat preservation ability. In order to decrease invalid water flow it is demanded that the tap should flow out water in 3~7 seconds.

Using the heat exchangers with high efficiency, in recent years our country has developed spring tube bundles heat exchanger and heat exchanger according with the uniform field theory, these heat exchanging equipments can get rid of dirt of heating equipment, strengthen the heat transfer efficiency and save energy^[8,10].

In order to make use of energy reasonably in entire society, it is advocated to use electricity for construction corporation in bottom stage of electricity^[7,8,9,10]. Therefore the techniques for storage heat and storage cooling come into being. The electricity in bottom stage of electricity has been used by heating, air conditioning system and living hot system, but now it is not widely used because the primary investment is higher than usual and it has been used by a few projects. Once the price of electricity in bottom stage continue to degrade and the materials for storage heat and cooling could be developed adequately, this system would be sure to make a improve.

8. CONCLUSION

In order to achieve the sustainable energy

provision and harmonious development of society, the energy used in building must use renewable energy and energy saving techniques. At present the utilization of geothermal heat and solar hot water system have been put into practice successfully, it can be widely used because the utilization of heating techniques of floor radiation, the techniques of saving energy such as heat preservation for outer wall and heating techniques for floor radiation, air conditioning techniques has been succeeded gradually, heat exchanging equipment with high efficiency has been developed, all these will be sure to encourage China to save the energy used for building and to use energy without pollution.

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