SWC—DEVELOPING SITUATION FOR

SOLAR HEATING COMBISYSTEMS IN CHINA

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1. Abstract

In recent years solar heating combisystems have been developed faster in China and a technical supporting system including technical code, computer design software and design handbook has been formed. At the same time many demonstration projects of solar heating combisystems have been completed in China. A brief introduction of the developing situation for solar heating combisystems including technical supporting system and the demonstration projects etc will be given in the paper.

2. Developing situation

For promoting the renewable energy application in buildings and raising the effect of solar heating in energy efficiency buildings, China government has paid more and more attention to solar heating combisystems in recent years. After 2000 solar heating combisystems started to develop and it is an important transition duration from demonstration projects to application on large-scale during 2010 to 2015 in China. So a technical supporting system for solar heating combisystems has been formed in China. In 2009 national standard 《Technical Code for Solar Heating System》GB 50495—2009 was issued and implemented. A computer software for design of solar heating combisystems has been developed by China Academy of Building Research (CABR) and a design handbook for solar heating meeting the case of GB 50495 compiled by Zheng Ruicheng etc will be published in the end of 2011.

As having central and local government's financial support many demonstration projects of solar heating combisystems have been completed in China in these years. One important application area is rural areas where the peasants have higher living level and the most projects were built in rural areas of Beijing. Nowadays building areas using solar heating combisystems are about over 300,000 m^2. The distribution is as Fig.1 and we can see that the most systems were built in Pinggu District, the ratio is about 65 %.

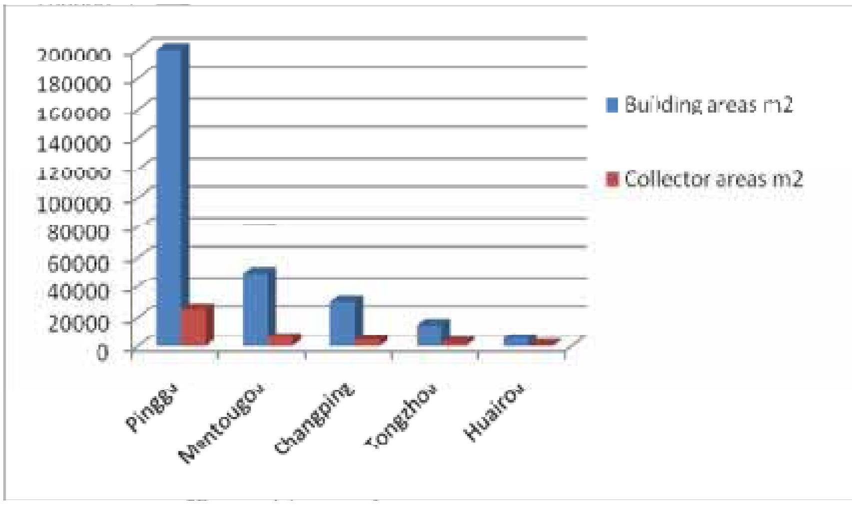

Fig. 1: Distribution of solar heating combisystems built in Beijing

The other important areas are west areas in China such as Qinghai Province, Inner Mongolia and Tibet Autonomous

Regions etc. In Qinghai Province solar heating combisystems will be installed for 23 boarding primary and middle schools of 250,000 m^2 total building areas in 4 Tibet autonomous prefectures and have got financial support from local government. In Urad Zhongqi of Bayannur City of Inner Mongolia Autonomous Region China's first solar heating combisystem with seasonal heat storage has been completed. In Tibet Autonomous Regions many important commercial buildings using solar heating combisystems were built in these years, such as Lhasa Railway Station, Liuyuan Coach Station in Lhasa (Fig.2), Libratory of Tibet University and Logistics Center of Qinghai-Tibet Railway in Naqu etc, the total building areas are over 1,000,000 m^2. The Logistics Center with an elevation of 4500 meters in Naqu is the highest logistics center of the world. The heat pipe evacuated tube solar collectors of heating combisystem in this Center are installed on the roofs of 4 storehouses in the Center, total areas of solar collectors of the system are 7800 m^2 (Fig.3).

Fig. 2: Liuyuan Coach Station in Lhasa

Fig. 3: Solar collectors installed in Logistics Center of Naqu

Except the demonstration projects, some solar heating combisystems were installed in their own buildings of many solar enterprises, such as office building of Beijing Hailin Energy Technology Inc (Fig. 4). The space heating for this office building is used solar heating combisystem and ground-source heat pump system. Solar collectors are used instead of part of curtain wall and roof panels of this building, so total construction cost decreased to only 2843 RMB / m^2. As it is an energy efficiency building, the energy consumption for space heating is only 8 W / m^2 and solar fraction of space-heating is about 7%.

Fig. 4: Office building of Beijing Hailin Energy Technology Inc

These solar heating combisystems have got and will get very nice energy saving effects. Therefore the successful experiences of these demonstration projects have been or will be referenced by other similar projects and will promote the further develop for solar space heating application in China.

From 2006 China government started many demonstration projects for renewable energy application including solar heating combisystems, the important ones are: " the Demonstration Items for Renewable Energy Application in Buildings " (359 projects altogether from 2006 to 2008) and " the Demonstration Cities and Counties for Renewable Energy Application in Buildings " (28 cities and 30 counties in 2009, 17 cities in 2010) supported by the Ministry of Finance and Ministry of Housing and Urban-Rural Development of PRC, "Demonstration Items for Green Counties" (108 counties in 2010) supported by National Energy Administration, the Ministry of Finance and Ministry of Agriculture of PRC. From 2011 some new demonstration projects will be started, such as "Green Small

Towns" and "New Energy Cities" etc. As having government support, so solar heating combisystems in China will be developed faster in the future.

3. Technical supporting system

3.1 National standard

In 2009 national standard 《Technical Code for Solar Heating System》GB 50495—2009 (shown in Fig.5) was issued by the Ministry of Housing and Urban-Rural Development of P.R.C and General Administration of Quality Supervision, Inspection and Quarantine of P.R.C. The issue date is 19, March 2009 and the implementation date is 1, August 2009.

The contents of the standard have 5 clauses, 7 annexes and explanation of the provisions. The clauses are 1. General Provisions, 2. Terms, 3. Solar Heating System Design, 4. Solar Heating System Installation, 5. Solar Heating System Adjusting, Commissioning and Benefit Evaluation. The annexes are A. Compensative Area Ratio of Solar Collector in Different Areas, B. Weather Parameters in Representative Cities and Recommendation Values of Solar Fraction in Different Areas, C. Calculation for Average Thermal Efficiency of Solar Collector, D. Calculation for Heat Loss of Pipelines and Water Tank in Solar Collector Loop, E. Calculation for Heat Exchanger Area of Indirect System, F. The formula for Benefit Evaluation of Solar Heating System, G. Properties of Common Phase Changeable Materials.

In the clause of Solar Heating System Design some design parameters such as recommendation range of collector flow rate and volumes of water storage tank of per m^2 collector etc and formula for calculation of collector areas are given. For insuring system safety a requirement is stipulated in the code that when seasonal heat storage is over, the reachable highest water temperature in water storage pool should be evaluated and this temperature must be lower than 5℃ from the water boiling point at the corresponding working pressure in water pool.

Fig. 5: National standard and software

3.2 Computer software

《Design Software for Solar Heating and Cooling System 》is developed by CABR and it was one of the tasks of China's national research projects. The software can be used for design of solar water heating systems, solar heating combisystems and solar cooling systems. For solar heating combisystems there are three databases and four function modules in the software. The starting surface of the software is shown in Fig.5.

Three databases are weather database, performance parameters database of the solar collectors and the graphics library of node-structure drawings for collectors integrated in buildings. Four function modules are load calculation module, system type selection & design module, system resistance calculation module and analysis module for energy efficiency and environment protection effect of the system.

The capacity of the load calculation module is to calculate heating load of the building which will install solar heating combisystem. According to national standard 《Technical Code for Solar Heating System》GB 50495—2009, the load is heat loss of the building in the condition of average outdoor temperature in heating season and indoor space heating computation temperature which is from 12℃ to 24℃ in China.

The capacity of the system type selection & design modules is to select system type, to determine the collector type, collector area, volume of water tank or pool, to select auxiliary heating equipment, to determine the energy consumption of the auxiliary heating equipment and to evaluate the reachable highest water temperature in water storage pool when seasonal heat storage is over. For determining the collector areas this module will calculate the local monthly average daily solar irradiation and irradiance on the slope plane of collector installation, and to determine the efficiency of the collector using efficiency equation of the selected collector which can be got from the performance parameters database of the solar collectors in software or can be inputted by user.

The capacity of system resistance calculation module is to calculate each length pipe diameter of the system and to determine the equipment such as pumps, expansion vassal and liquid storage vassal etc.

The capacity of the analysis module for energy efficiency and environment protection effect of the system is to calculate the practical solar fraction of system, yearly energy saving cost, the total energy saving cost in life period of the system, solar heat-cost, payback years for increased solar system investment and decreased quantity of exhausted CO_2.

The output of the software is selected system and collector types, collector areas, volume of storage tanks or pools, the reachable highest water temperature in water storage pool when seasonal heat storage is over, model and capacity of pumps and heat exchangers, solar heat-cost, payback years for increased solar system investment, decreased quantity of exhausted CO_2 and node-structure drawings of CAD type.

3.3 Design handbook

《Technical Handbook for Solar Heating System》is a detail guideline for design, construction, acceptance and evaluation to solar heating combisystems meeting the requirement of national standard 《Technical Code for Solar Heating System》GB 50495—2009. Some important design parameters and computation methods are given in the handbook, such as an experience formula for evaluation of the highest water temperature in water storage pool when seasonal heat storage is over, evaluation methods for energy saving effect and environment effect etc. Three real projects including two systems with short-term heat storage and one system with seasonal heat storage are introduced in the last chapter of the handbook, so the engineers can understand the design measures of solar heating combisystems very directly. The handbook will be published by China Architecture & Building Press in the end of this year. After publishing of this handbook, we will conduct some training classes to teach national standard and handbook of solar heating combisystems.

4. Demonstration projects

4.1 The project with seasonal heat storage

4.1.1 Brief introduction of basic situation

A district solar heating combisystem with seasonal heat storage in Urad Zhongqi of Bayannur City of Inner Mongolia Autonomous Region has been completed in 2010. It is a demonstration project for renewable energy application in buildings getting financial support from the Ministry of Finance and Ministry of Housing and Urban-Rural Development of PRC.

This solar heating combisystem with seasonal heat storage is for heating to two residential districts (Xinlongcheng and Jiahe residential district). There are 14 residential buildings in Jiahe residential district, building area of each residential building is 4500 m^2 and the total building area is 63,000 m^2. There are 20 residential buildings in Xinlongcheng residential district, building area of each residential building is 5000 m^2 and the total building area is 100,000 m^2. The total apartments are 1520 in these two residential districts.

The solar collector of this solar heating combisystem is glass-metal heat pipe evacuated tube collector and it's efficiency equation based on gross collector area is as follow: $\eta = 0.554 - 1.562\ T^*$.

The design total areas of solar collectors of the system are 11994 m^2 and water storage pool is 13250 m^3, but in the first step of the project only 5000 m^2 collectors and the 3500 m^3 underground water storage pool were completed. The collector installation tilt angle is 45^0 and orientation of the solar collectors are faced to south. In the system some testing equipment was installed and the testing data can be transferred to computer by internet.

Fig. 6: Solar collector system in solar heating combisystem with seasonal heat storage of Urad Zhongqi

4.1.2 Effect analysis

After design scheme of this project was finished, a pre-evaluation for energy saving and environment effects of this project was given by design engineer. According to original design scheme, the heating load of the combisystem is 2315 KW, solar fraction is 40 %, so the total useful solar heat gain is 29,551,955 MJ / year, including 12,033,064 MJ heat gain in heating season, 1,941,721 MJ heat gain for heat storage in the pool and 15,577,170 MJ heat gain for hot water supplying in other seasons. When heat storage is over, the highest water temperature in the pool is 95℃. If working life of the combisystem is considered as 15 years, in whole life the total energy saving of the system is 67,079,339 MJ and the cost of the energy saving is 37,890,100 RMB.

The energy saving of the combisystem in whole life is equal to 34,333 TCE, so decreasing quantity of exhaust CO_2, soot, SO_2 and NO_x is 91,391 Ton, 343 Ton, 687 Ton and 50 Ton respectively.

The investment of the combisystem is 40,000,000 RMB, local coal cost is 1600 RMB / Ton and electricity cost is 0.526 RMB / kWh. Under this condition, solar cost of the combisystem is 0.14 RMB / kWh and pay-back year of the project is 6.4 years.

4.2 The project with short-term heat storage

4.2.1 Brief introduction of basic situation

Solar heating combisystems in the peasant houses at some villages in Pinggu District of Beijing are demonstration projects of the item “New Countryside Construction” in Beijing. All solar heating systems which installed in the peasant houses can get financial subsidy from local government and some of them can get subsidy from an item of “the demonstration project for renewable energy application in buildings” supported by the Ministry of Finance of P.R.C and the Ministry of Housing and Urban-Rural Development of P.R.C. The financial subsidy from government of Pinggu District in Beijing is 20,000 RMB for one family who installed solar heating system.

Fig. 7: Solar collector systems on the roofs of peasant houses in Pinggu District of Beijing

The range of building area of each house installed solar heating system is 90～210 m^2 and the solar collector areas, volumes of water tanks in different houses are 14～60 m^2 and 0.3～1.5 m^3 respectively in Pinggu District. The pictures of solar collector systems on the roofs of peasant houses in Pinggu District of Beijing are shown in Fig. 7.

4.2.2 Effect analysis

For evaluating the effects of these solar heating projects, National Center for Quality Supervision and Testing of Solar Heating Systems (Beijing) selected one family house as testing object in 4 villages respectively, altogether 4 houses. In this paper it is only introduced the testing results and the effect analysis of solar heating system in the family house of Guajiayu village. The collector area of the testing house in Guajiayu village is 24.21 m^2, using flat plate collectors installed on the slope roofs. The volume of heat storage water tank is 1.5 m^3. The space heating type is low-temperature floor panel heating.

According to testing for a peasant house at Guajiayu village in Pinggu District of Beijing by National Center for Quality Supervision and Testing of Solar Heating Systems (Beijing), the solar heating combisystem installed in the peasant house can save about 1.143 TCE in winter and 0.236 TCE in the other seasons, so total energy saving in one year is 1.379 TCE and decreasing for CO_2 discharging in one year is 3.671 Ton. The average room temperature is 12 ℃ in winter when no other assisted heating energy source, so solar fraction is 100% in this condition.

The project (solar heating systems of all 71 families in Guajiayu village) can save 978.4 Ton coal equivalent in winter and 133.3 Ton coal equivalent in the other seasons. In one year the total energy saving is 1111.7 Ton coal equivalent and decreasing for CO_2 discharging is 2745.9 ton.

5. Conclusion

China is the largest market of solar hot water systems in the world now and the solar heating combisystems are the next application technology spreading in China. As having better saving energy and environment effects, in 2020 we hope that there will be 300,000 m^2 installed solar collector areas for solar heating combisystems which are national aim's 1 ‰ of 300,000,000 m^2 installed solar collector areas and can get more energy saving effects.

Nowadays and in near future the most suitable areas to use solar heating combisystems in China have two. One is west areas where solar resources are very rich, having longer winter, fewer population and larger lands, such as Tibet, Xinjiang, Inner Mongolia Autonomous Region and Qinghai, Gansu, Ningxia Province etc. Another is east rural areas near big cities where having higher economy lever and peasant's income, as most of building types are two-storey, so having enough roof areas to install solar collectors.

In west areas government should give some financial support to build solar heating combisystems. But in east areas maybe solar heating combisystems can be built through market and government's promoting policy.

For getting better energy saving effect, solar heating combisystems should be used in whole year and can reach this object through reasonable system design: space heating in winter and hot water supply in other seasons.

6. References

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