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Compulsory Policies of Installing Solar Water Heating Systems and Normative Construction Procedure in China

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Abstract

In recent years many local governments in China have implemented compulsory policies of installing solar water heating systems integrated in new buildings. So system quality and capacity becomes a very important problem. Therefore a complete supervision system for quality control to solar water heating systems integrated in buildings during whole construction procedure has been formed gradually in China. This system includes technical code for design and acceptance, performance requirement to products of solar collectors and a normative construction procedure etc.

In this paper it is given the background of compulsory policies of installing solar water heating systems integrated in new buildings and introduced a normative construction procedure for solar water heating system. The procedure runs through design, product selecting, construction, acceptance and evaluation. As most of buildings are tall buildings in China's cities some installation types for solar collector integrated in buildings and better operation measures for central solar water heating systems to suitable special condition of China are also given in the paper.

Key-words: *compulsory policies; technical code for design and acceptance; construction procedure for solar water heating system*

1. Background

In recent years many local governments in China have implemented compulsory policies of installing solar water heating systems integrated in new buildings, and some cities publish different preferential policies, such as give financial subsidy to star green residencies which should take certain technical measures including installation of solar water heating systems etc. But some problems occur when practice, such as substandard product quality and completion inspection of projects etc. As it has influenced the health developing of these polices, for quality control and capacity promotion of the solar water heating systems, a completed supervision system has been formed gradually in China.

The system includes three important aspects. The first is national standards for products, such as "Evacuated tube solar collectors" and "Flat plate solar collectors" etc. The second is technical code for design and acceptance, such as "Technical code for solar water heating systems of civil buildings" and "Evaluation standard for solar water heating system of civil buildings" etc. The third is a normative construction procedure. Only following this construction procedure a solar water heating system integrated in building with higher quality and better effect can be completed. The procedure has 4 main steps: design, installation, acceptance and evaluation.

2. Design, examining and approving for design drawing

Engineering design in China must follow a stipulate procedure and the design for solar water heating systems

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integrated in buildings should also follow it. The most important step for the procedure is examining and approving to design drawing by another qualified authority after design is finished by original design authority.

2.1. Design

Design for solar water heating system integrated in building shall be done by an authority which has a certain design qualification. Design must follow the all stipulation in China's national standard "Technical code for solar water heating systems of civil buildings" GB 50364. This code has finished revision during 2014-2015 and many terms in revision version of the standard can give stronger supporting to guarantee the design quality.

For example, the term for calculating solar collector areas used in system stipulates strictly that yearly average efficiency of the solar collector shall be calculated according to the instantaneous thermal efficiency equation of a solar collector which is tested by a qualified testing authority and computation method is given in this term. The computation method of this term gives the detail selecting principle for computation parameters, such as how to select solar irradiance, ambient temperature and inlet water temperature of collector in reduced temperature difference of the thermal efficiency equation.

The revision version of the standard gives a lot of basic data used for design, such as yearly total solar irradiation and average daily total solar irradiation on horizontal and slope plane in 31 cities of China etc. In appendixes of the standard some computation methods are given, such as computation for wind load to a solar water heating system which installs on the roof of a tall building. So the revision version of the standard is a more useful design tool and can raise future design level of solar water heating system in China.

2.2. Examining and approving for design drawing

After the design for solar water heating system be finished all design materials including design drawings, calculation documents etc must be examined and approved by another authority which has a certain level of drawing check qualification.

The focus of design examining by the drawing check authority are following:

• If the design meets all stipulations in national standard " Technical code for solar water heating systems of civil buildings" GB 50364, such as various safety requirements, calculation for solar collector areas and volume of water tank etc, type selection for equipments of pump and heat exchanger etc.

• If the performance of the solar collector used in the system meets the technical requirement in concerned national standard, such as exposure and pressure-resisting etc safety performance, zero-loss collector efficiency and collector overall heat loss coefficient etc thermal performance.

• If having the reliable and flexible automatic control measure and it can prevent effectively occurring of safe faults, such as overheating and freeze of the system etc. And the control measure can give precedence to use solar energy heating water etc, so to guarantee energy saving effect of the system.

• To check the analysis for energy saving effect and economical efficiency of the system design and if it meets the original requirement.

Only an approved design scheme can be used for construction of a solar water heating system integrated in building.

3. Requirement for installation and acceptance of system construction

Requirement for installation and acceptance of a solar water heating system is stipulated in "Technical code for solar water heating systems of civil buildings" GB 50364 and acceptance is a key factor. In the revision version of the standard GB 50364, more contents are added in the chapter of acceptance for solar water heating systems, so the operability to an engineering acceptance for a solar water heating system is stronger and clearer than before, therefore the engineering quality and the effect of the solar water heating system will also has a better guarantee than before.

The standard stipulates that acceptance shall be divided into acceptance for itemized project and completion acceptance and system commissioning must be finished before completion acceptance. Acceptance for concealed work, such as embedded parts for collector installation foundation etc, must be certificated by supervision personnel of the project before concealing. After each acceptance for itemized project finished, linkage debugging to the system shall be carried out and then system commissioning must be done as practical working condition in continuous 3 days which shall be one clear day at least. When linkage debugging, temperature, flow rate and working pressure of the system shall meet the design requirement at the rated condition in which flow rate and temperature of hot water supplying equals design value.

When completion acceptance, some necessary documents, such as completion drawings, qualified certificate or performance testing reports of the main materials and equipments, records for system debugging and commissioning, testing record for thermal performance of the system etc must be given. Testing for thermal performance of the system shall be done in 4 days when having different solar daily irradiation at least, the distribution range of solar daily irradiation (shown in Table 1) and testing method shall meet the requirement in China's national standard "Evaluation standard for application of renewable energy in buildings" GB / T 50801. Only passed the completion acceptance, the engineering of a solar water heating system can transfer to users.

Tab. 1: Distribution of solar daily irradiation for thermal performance testing of a solar water heating system

days	the first day	the second day	the third day	the fourth day
daily irradiation (H)	H＜8 MJ/m^{2}d	8 MJ/m^{2}d≤H＜12 MJ/m^{2}d	12 MJ/m^{2}d≤H＜16 MJ/m^{2}d	H＞16 MJ/m^{2}d

The defects liability period for engineering quality of a solar water heating system is two years. In this period if some quality problems occur, the construction authority shall take maintenance and the responsible party shall undertake concerned economical duty.

4. Some better technical measures for solar water heating systems

As most of buildings are tall buildings in China's cities, so installation types for solar collector integrated in buildings and operation measures shall be suitable to this special condition.

4.1. Installation types for solar collector integrated in buildings

As roof area is not enough to install solar collectors which can meet demand of solar water heating system for a tall building, two main installation types are used generally in China, collectors close putting on a support structure of the roof (Fig.1 left) and collector instead of board of balcony (Fig.1 right).

Fig. 1: Two main installation types for solar collectors integrated in buildings

For installation type of collectors close putting on a support structure of the roof, in general the system can provides enough solar hot water supply to whole building which has 24 floors. As collector frame can shelter incidence sunlight, the another advantage of this installation type is to decrease the roof temperature

in summer, according to testing to a real project in Shenzhen City the roof temperature is 2℃ lower than common building, so it is favor to decrease energy consumption for air conditioning in summer.

Fig. 2: View of real projects using these two installation types for solar collectors

For installation type of solar collector instead of board of balcony the tilt angles of the collector installation are different in north part with higher latitude and in south part with lower latitude of China. In north part with higher latitude, such as Heilongjia Province etc, the tilt angles of the collector can be 90^0 (Fig.1 right), but in south part with lower latitude, such as Jiangsu Province etc, the tilt angles of the collector shall be smaller than 90^0 (Fig.2 right), so can get more incidence sunlight.

4.2. Operation measures for a central solar water heating system

For increasing energy saving effect of a central solar water heating system, it is necessary to decrease heat loss in circulation pipes of hot water supplying. So a common operation measure for hot water circulation in pipes used in China is to start circulation only when temperature of hot water is lower than a set value in the past. But now a better operation measure for hot water circulation is used in some residential buildings, circulation starting only when a user wants to use hot water. If a user in the building wants to use hot water, he/she can put a push-button on the wall of an apartment to start circulation (push-button flashing) and then use hot water till the push-button no flashing, as it (push-button no flashing) means that the temperature of hot water has reached the set value and can be used for bath etc, not only energy saving but also water saving.

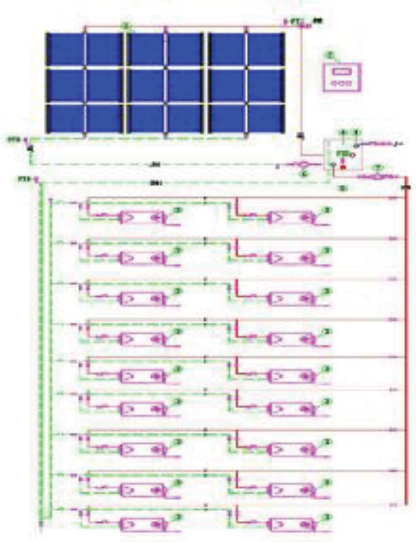

Fig.3 shows a popular central solar water heating system which is named collective-individual hot water supply system. Solar collector array of this system is installed on the roof of a tall building, and the hot water storage tanks are installed in each apartment of the building, but a small solar hot water tank is on the roof. Solar hot water is supplied into heat exchanger of water storage tank in the apartment and water in the tank is heated. The main advantage of this system is to make easier for payment of hot water using. The increasing cost for solar water heating system can be included in sale price of the apartment, the resident family need only take cold water payment when using solar hot water, so heat metering of the system can be canceled. As a possible problem of the system is unbalances heat exchange between various water storage tanks, so developed an auto-control measure to solve it. Every time heat exchange is only taken between users of selecting numbers (adjustable as real condition), not all users.

Fig. 3: Collective-individual hot water supply system

At the first round when water temperature of these tanks raise 5℃ (adjustable as real condition, in general it is 5-10℃), the hot water input valve of heat exchangers close automatically and heat exchange turn to next sets of same number's tanks for heat exchange, repeating till finishing heat exchange of all tanks, then to the

second round, so guarantee to get same solar energy for all users basically.

5. Effectiveness

Since following this normative construction procedure for solar water heating systems, many projects of solar water heating system get better effects than before in China. For spreading successful experience of better projects, China Academy of Building Research undertook a task for compiling drawing volume of excellent cases of solar water heating systems which is given by the Ministry of Housing and Urban-Rural Development of PRC in 2015. China Academy of Building Research investigated a lot of projects and National Center for Quality Supervision and Testing of Solar Heating System (Beijing) tested some projects for volume compiling and 18 engineering cases of solar water heating system are selected to put into the drawing volume.

These 18 engineering cases are located in 9 Provinces including Beijing Anhui Hebei Shandong Jiangsu Zhejiang Hainan Xinjiang Ningxia and cover 4 different weather areas of severe cold zone, cold zone, hot summer and cold winter zone, hot summer and warm winter zone in China. The system types of the cases are 7 collective hot water supply systems, 6 collective-individual hot water supply systems and 5 individual hot water supply systems. So the cases have a wide-ranging representativeness. The average solar cost of the cases is 0.11Yuan/kWh and the payback period of steady state is all smaller than 5 years, economical efficiency is very nice.

Tab.2 and Tab.3 shows a fine effect of an understanding case in the drawing volume. It is a central solar collective and hot water supply system in a living building for staff of Yimin Company, located in Nanpi County, Cangzhou City, Hebei Province, designed and installed by Jiangsu Sunrain Solar Energy Co.,Ltd which is exclusive quoted company in solar thermal field of China. Total solar collector areas of the system are 620m^2, except solar hot water supply to the building, surplus solar hot water will be transported to ground heat exchanger of a ground-souse heat pump system which is for space-heating of this building. As soil temperature will be raised through heat exchange with solar hot water, unit COP of ground-souse heat pump can be raised, so system efficiency will be also increased.

Tab. 2: Testing data for thermal performance of the project in Yimin Company Ltd

Day	Outdoor temperature ℃	Daily solar irradiation MJ/m^2	Daily solar heat gain MJ	Common energy consumption MJ	System efficiency %	Solar fraction %
1	-3.2	16.52	4241.5	0	47.7	100
2	-2.8	14.83	3983.4	0	49.9	100
3	-1.1	11.54	2545.1	804.5	41.0	76.0
4	-0.3	6.38	1234.8	2114.8	36.0	36.9

Tab. 3: Analysis results for energy saving and environment effects of this project in Yimin Company Ltd

Items	Unit	Value
Solar fraction in one year	%	81.6
Average system efficiency in one year	%	44.2
Quantity instead of common energy	tce/year	127.5
Decreasing quantity of CO_2 discharge	t/year	314.9
Solar cost	Yuan/kWh	0.04
Saving cost in one year	Yuan	498,978.00
Payback period of steady state	Year	1.4

From Tab.2 we can know that this system can get fine thermal performance even in winter. When sunny day solar fraction of the system is still attain 100%. From Tab.3 the energy saving effect and economical efficiency of the system is also very nice. Solar fraction of the system in one year is over 80%, solar cost is only 0.04 Yuan/kWh and payback period of steady state is 1.5 year, very short. The drawing volume of excellent cases of solar water heating systems will be published and as a teaching material for training. So we can believe that solar water heating systems integrated in buildings will be developed better and more healthy in China.

6. References

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