Development of Solar Thermal During 2011 to 2015 and Developing Anticipation for the Technology During 2016 to 2020 in China

Ruicheng Zheng[1], Tao He[1], Xinyu Zhang[2], Min Wang[2] and Bojia Li[1]

[1] China Academy of Building Research, Beijing (China)

[2] Committee of Solar Thermal Conversion, China Renewable Energy Society, Beijing (China)

Abstract

In this paper it is introduced the development of solar thermal including solar hot water, solar heating combisystem, solar cooling, solar drying, solar cooker, solar desalination and solar thermal power etc during 2011 to 2015 and looking forward to these technologies developing including anticipation for technique progress and projects spreading during 2016 to 2020 in China.

Keywords: solar hot water, solar heating combisystem, solar cooling, solar drying, solar cooker, solar desalination, solar thermal power

1. Introduction

There are two influence factors for development of solar thermal during 2011 to 2015 in China. The favorable factor is policy supporting from governments, such as "the Demonstration Items for Renewable Energy Application in Buildings" supported by the Ministry of Finance and Ministry of Housing and Urban-Rural Development of PRC and demonstration projects of "Green Small Towns" and "New Energy Cities" supported by National Energy Administration, the Ministry of Finance and Ministry of Agriculture of PRC etc. The unfavorable factor is market environment. As national economy developing speed changing slowly especially gliding of real estate which has a close relation with solar thermal, developing of solar thermal also meet some difficulties. So it is necessary taking positive and useful measures to overcome them on the base to sum up the past experience for China's whole profession of solar thermal.

China's fast developing of solar thermal mainly depended on application of solar hot water in the past and now this market becomes saturated. Therefore an important countermeasure is extending application fields, such as from solar water heating system extending to solar heating combisystem, from solar heat for buildings extending to solar heat for industrial and agricultural processes and we will have a rather favorable circumstances in the next years. For decreasing serious air pollution, in the 13th Five-year plan (from 2016 to 2020) China government has decided a higher goal for renewable energy application and especially has made a guiding principle on cleaning space heating in countrysides of northern China. So under this background we can anticipate hopefully that solar thermal in China will have a better development in the future, and we should pay more attention to technical progress which includes raising product quality and improving system optimum design etc. At the same time we should also promote the international cooperation with developed countries having advanced technology of solar thermal and raise our ensemble capacity.

2. Development of Solar Thermal During 2011 to 2015

2.1. Industry of solar thermal

China has the largest solar thermal industry and market in the world. But it is different with many developed countries where the flat-plate solar collectors are the main products; manufactures for evacuated tube solar collector are still the most, although some manufactures have started to produce flat-plate solar collectors during these years in China. Figure 1 is shown year-quality of sale for collectors and the figure 2 is capacity in operation of solar thermal systems from 2005 to 2015 in China. We can know from these two figures that 2013

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is a changing year, the year-quantity of sale for collectors decreased after this year, but the capacity in operation of solar thermal systems has still a little increasing.

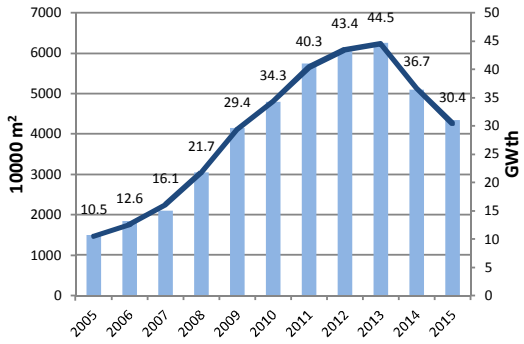

Fig. 1: Year-quantity of sale for collectors

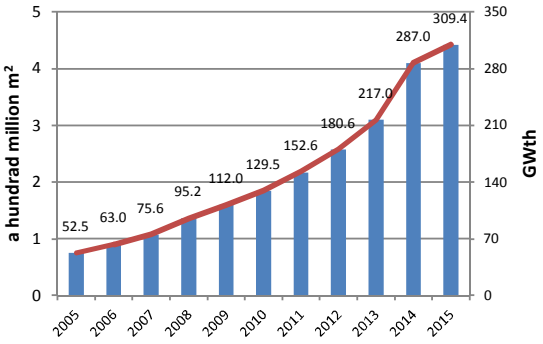

Fig. 2: Capacity in operation of solar thermal systems

2.2. Developing for new products

During 2011 to 2015 China enterprises of solar thermal developed following two key new products:

- Evacuated tube solar collector reaching 150 ℃ working temperature, when reduced temperature difference T_m* is 0.13 (m^2℃) / W, the collector instantaneous efficiency is 53%, its efficiency curve is shown in fig.3. The scale of year output can get three hundred thousand evacuated tubes and one hundred thousand collectors.
- Selective coating for flat-plate solar collector, absorptance is 0.94～0.95, emissivity is 0.05～0.07 and having better anti-aging performance. Automatic production lines for absorber plate with selective coating have been built in Sichuan, Shandong and Fujian provinces etc. The whole production capacity is 11 million m^2 and having own intellectual property.

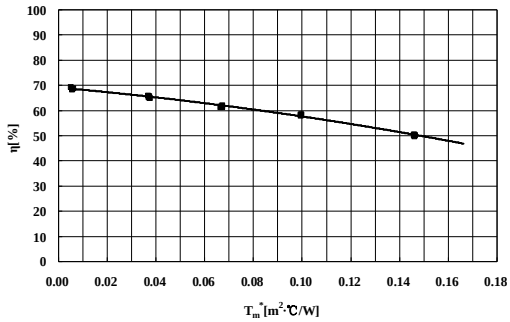

Fig. 3: Efficiency curve of collector

Fig. 4: Collector instead of balcony railing for a solar hot water system

The other important new product is solar air collectors having different structure types and some solar air collectors have realized industrialization.

2.3 Solar water heating system

During 2011 to 2015 application for solar water heating systems had some bigger progress and mainly reflected following three aspects:

- National standard 《Minimum allowable values of energy efficiency and energy efficiency grades for domestic solar water heating systems》 GB 26969-2011 was published and practiced in 2011. The standard gives the energy efficiency grades according to the coefficient of thermal performance for domestic solar water heating systems. There are three levels of energy efficiency grades, the highest is first level and the threshold enter to market is to reach the third level. So some worse quality domestic solar water heating systems are limited to sell in the market.

- As high-rise residential buildings in the cities are main users of solar hot water in China, so some suitable system types are developed to meet this special situation, such as collective-individual system (collective installation of solar collectors, individual installation of water tanks in each apartments) for easy hot water metering. At the same time to develop some new models for solar collectors integrated in buildings, such as collector instead of balcony railing (shown in Fig.4) etc and suitable installation measures to raise the safety and reliability for meeting the requirement of compulsory installation polices.

- Some new system auto-control measures are developed and got practical application, such as household heat exchange control to reach well-distributed heat supply for a collective-individual system. Heat metering was widely used; performance testing for a solar water system on site has became usual business of national or local testing agencies in China. Some projects have realized long term performance monitor and testing data can be delivered by internet.

2.4 Solar heating combisystem

Developing of solar heating combisystem is since 2000 in China and it is an important transition from demonstration projects changing to scale application duration 2011 to 2015. National standard 《Technical code for solar heating system》 and complement《Technical Handbook for Solar Heating》published and in practice in 2009 and in 2012 respectively, so give a stronger technical support to application of solar heating combisystem in China. Most projects of solar heating combisystem used short-term heat storage and application for solar heating combisystems with seasonal heat storage is still at the staring stage in China, but following two projects established a better foundation to developing of solar heating combisystem in the future.

- More than 0.4 million m^2 building area of peasant residences using solar heating combisystems with short-term heat storage have been built in suburbs of Beijing (Fig.5). From monitoring to the solar heating effects in a typical residence during whole winter, solar fraction is 100% in the case of room average temperature 12℃ and the highest room temperature 16℃. The solar cost of the system is 0.44 RMB / kWh, when the working life of the system is 15 years.

- For solar heating combisystems with seasonal heat storage, the technical level and application scale of China have a bigger difference compare with developed countries such as Denmark, Germany and Canada etc. Therefore the international cooperation project "Sino-Danish Renewable Energy Development Programme: Testing, Research & Demonstration for Large Scale Solar District Heating Systems" which was finished in 2015 gave a lot of best experience to China's technicians and will promote its better application in China in the future.

Fig. 5: Peasant residence of solar heating in suburb of Beijing

Fig.6: Parabolic-trough collectors for solar cooling

2.5 Solar cooling

Technology of solar cooling is developed since 1970's in China but its application is still at the demonstration stage. Following is some achievements in this field during 2011 to 2015.

- To develop heat-operated refrigerating machine be suitable to solar application, such as 50 kW adsorption refrigerating machine and 1.N-effect absorption refrigerating machine etc.

- National standard 《Technical code for solar air conditioning system of civil buildings 》GB 50787-2012 was published and practiced in 2012.

- A solar adsorption air conditioning system (the total area of the solar collectors is 49.4m^2) was successfully used to a national grain depot and got better effects. At the condition of daily solar irradiation 16-21 MJ / (m^2 day), the average daily refrigerating power is 3.3-4.4 kW and operation time of the refrigerating machine in the system is 6.5-8.5h during each day.
- A solar lithium bromide absorption air conditioning system (323m^2 solar collectors and 35kW refrigeration unit) was completed in 2013 and has being stably worked till now. Average solar fraction during whole summer can reach 83% in the case of average environment temperature 32℃ and room average temperature 26℃ and average efficiency of the solar collector system is 50%.
- To develop a lower cost parabolic-trough collector for solar cooling and build some demonstration projects of solar air conditioning (Fig.6). According to the on-site testing for a demonstration project in 4 days having different solar radiation, average efficiency of the solar collector system is 55% and the average solar fraction is 68% in the case of 30℃ average environment temperature and 25.6℃ average room temperature.

2.6 Solar drying

Before 1980's there are only 4 solar drying devices of 183 m^2 total collector areas, but it developed faster after 2000 in China. At the present more than 200 solar drying systems were built and total solar collector areas are more than 4 million m^2, but the most is small system with collector areas lower than 200 m^2. There are two main types of solar drying device, using greenhouse or solar collector. The main drying materials are agricultural products including grain fruit and tobacco etc, and industry products including wood (Fig.7) and building materials etc.

Fig. 7: Solar wood drying

Fig.8 Concentrating solar cooker of sheet steel

Professional standard 《General specification for solar drying system》 NB / T 34022-2015 was published and practiced in 2015. It is a first standard for solar drying in China and gives a very important guidance to optimum design and normal installation of the solar drying devices. As solar air collector is a key component of the solar drying device, national standards《Specification for solar air collectors》GB / T 26977-2011and《Test methods for the thermal performance of solar air collectors》GB / T 26976-2011 which were practiced in 2011 promoted the quality improving of solar air collector greatly.

2.7 Solar cooker

Solar cooker was developed since 1950's in China. As solar cooker has important action for the peasants in the areas where lack of fuel but having better solar radiation, its developing is always stable and the capacity in operation for solar cookers is more than 4 million nowadays in China. In normal using condition one solar cooker can save about 1000kg firewood every year and is about 2 years of paying back time for cost.

There are main two types of solar cookers, box solar cooker and concentrating solar cooker. As Chinese cooking habit, the most of type is concentrating solar cooker in China (Fig.8), box solar cookers are fewer. China's agriculture professional standard 《Focusing solar cooker》 NY / T 219-2003 is the first concentrating solar cooker product standard of this field in the world.

2.8 Solar desalination

China is one of the 13 poor water countries listed by UN and water resource per person is only 1/4 of the world average level. So solar desalination is a continual interest technology for long time in China, but it is still at the research and experiment stage, although to get some better results such as patent of invention "solar air injection desalination device" etc in recent years, there is not demonstration project of practical application up to now.

2.9 Solar thermal power

During 2011 to 2015 solar thermal power including four types of tower, parabolic-trough, dish and Fresnel was all developed at different level in China. Some enterprises have already the capacity to produce heliostat, Stryn generator and evacuated collector tube be used at parabolic-trough collectors etc. There are more than 14 enterprises who can produce evacuated collector tube be used at parabolic-trough collectors and more than 7 enterprises of producing heliostat in China. Part of products passed the testing of foreign professional agency and performance can reach international level. Several solar thermal power systems have been built in China, such as China's first 1MW tower solar thermal power station (Fig.9) located in Badaling of Beijing, generated in August, 2012 and 1MW dish Stryn solar thermal power system (Fig.10) located in Tongchuan of Shanxi Province, completed in 2016 and Stryn generators are developed and produced by Xian Aero-Engine Plc.

Fig. 9: Tower solar thermal power station in Badaling of Beijing

Fig. 10: Dish Stryn solar thermal power system in Tongchuan

3. Technique prospect for solar thermal during 2016-2020

In 2020 the renewable energy will be 15% of total final energy use in China and among them contribution of solar thermal is 13.7% share. Therefore solar thermal is a key technique for completing this object and we should make more efforts during 2016-2020.

3.1 Industry of solar thermal

The industry of solar thermal in China will enter a key transitional stage, only those enterprises which have technical innovative capacity can be developed faster and change stronger. Therefore some enterprises have started cooperation with concerned department in advanced countries for improving own technical capacity. The industry developing will focus to new products and technologies suitable to middle and high temperature application of solar thermal, such as evacuated collector tube with working temperature higher than 250 ℃.

3.2 Solar water heating system

As solar water heating systems integrated in buildings are main types of solar hot water application nowadays in China, the most important tasks are further raising the system's energy saving effects and quality improving of hot water supply. It is necessary focus to system optimum design, automatic-control, heat metering and to step up efforts recommending different types of fine solar water heating systems integrated in buildings by publishing atlas of excellent projects and holding various training etc. At the same time supervision to compulsory installation for solar water heating systems will be strengthened, so that the market can get further normalization.

3.3 Solar heating combisystem

Solar heating combisystem will realize scale application gradually as two favorable policy decisions from government in the future. One is winter space heating by clean energy in northern part of areas; another is to

supply space heating for buildings in Tibet.

Coal is the main energy for space heating in northern part of China and it is an important influence factor to cause air pollution in winter. Therefore the government makes a policy decision to change this situation by using clean energy for space heating instead of coal for decreasing air pollution. In this year a demonstration item for space heating using clean energy in northern part of areas has been initiated by 4 ministries together, the Ministry of Finance, the Ministry of Housing and Urban-Rural Development, the Ministry of Environmental Protection and National Energy Administration. The item can get different level's financial support from the Ministry of Finance according to city's size. As one of clean energies, solar heating combisystem can be practiced in the item and get a chance to develop faster in the future.

Although the weather is very cold in Tibet, but there is no space heating measures in buildings in the past. Therefore to supply space heating is a very important decision for improving living condition of Tibet people. Tibet has the best solar energy sources but lacks of common energies, so to build scale demonstration projects of solar heating combisystems in Tibet can solve space heating problem and avoiding environment pollution at once. Several projects of solar heating combisystems have been carried out in practical implement items for space heating of Tibet, at the same time in the national research plan of the 13th Five-year Development Plan, some research and application items of solar heating combisystem for space heating in Tibet have been also listed. It can be expected that China's technique level of solar heating combisystem will be raised substantially after these items completing.

3.4 Solar cooling

As PV cost decreased continuously in recent years, solar PV electric refrigerating comes into a fine developing chance and a discussion of comparison for solar PV electric refrigerating and solar thermal power refrigerating is resulted. But to China's condition most of areas need space heating in winter and air conditioning in summer, so solar thermal power refrigerating can get better effects and cost performance compare with PV electric refrigerating. Therefore solar cooling using thermal power refrigerating should still have more application and we should pay more attention to two aspects. One is to expand the application scale of solar cooling in suitable areas such as in Turpan of Xinjiang Uygur Autonomous Region where it is dry, hot daytime but cool at night in summer and solar radiation is very nice. Another is to raise technical level for new product research such as to develop small unit of refrigerating capacity lower than 50kW etc. Fortunately, a large demonstration project of solar cooling has been practiced in Turpan, and it will promote the technology progress of solar cooling in China through experience summarization of this project's design, construction and operation etc.

3.5 Engineering construction national standards

In the past there are two types of engineering construction national standard in China. One is mandatory standard which includes some (at least having one) compulsory provisions. The compulsory provisions are only concerning safety, personal healthy etc requirements and must be executed strictly. Another is voluntary standard which has not compulsory provisions. But this system will be reformed in the future, only mandatory standard is still national standard, whole texts are compulsory provisions in it and the provisions will include the requirements to capacity, performance and technical measures, except safety etc. Voluntary standard will be changed to professional or association standard and not be controlled by government. For getting better reforming results some items have been started to research the compiling principle and text contents included in each mandatory standard etc. As the importance of energy efficiency and renewable energy to economy developing, one of the items is "compiling research to code for energy efficiency and renewable energy application in buildings" which includes the contents of solar thermal application in buildings. After the item completing the next task is to compile "Code for energy efficiency and renewable energy application in buildings" according to the item's research results and this code will produce an advantage to standardize application of solar thermal in buildings as well as to improve its energy saving effects in China.

3.6 Solar drying

Most of solar thermal application including solar hot water, heating combisystem and cooling is in buildings in the past, but in the future more will be changed to the fields of industry and agriculture in China. Solar drying is a main technique type used in the fields of industry and agriculture, so it can be expected that solar drying will meet an excellent developing chance and have larger scale of application. In the aspect of technology progress,

we should focus attention on to develop solar air collectors which have high efficiency and can be suitable to solar drying systems for different materials, low cost heat storage devices and build more demonstration projects.

3.7 Solar cooker

Tourism industry developed very faster in recent years in China. So an important developing direction of solar cooker is to research and produce new box solar cookers which are easy carry, having low cost and used to field cooking such as barbecue etc for tour. Some enterprises have produced several model machines, the next step is to improving performance further and to form a certain manufacture scale.

3.8 Solar desalination

During 2016-2020 solar desalination should be changed from theory and experiment research to demonstration application in China. The main focuses are integrating technique for solar thermal system with common sea water desalinization, system optimum design, to raise economical efficiency and to build demonstration projects for solar desalination in the islands where lack of fresh water etc.

3.9 Solar thermal power

During 13th Five-year plan more demonstration projects for solar thermal power will be started in China and several projects of solar thermal power have been approved by the National Energy Administration. After these projects finishing and generating, they can get financial subsidies by 1.15 CNY/kWh of sales price to power network. Compared with PV solar thermal power can be combined heat and power production, so research for technology of heat and power cogeneration suitable to solar thermal power is one of the important tasks in the field of solar thermal power, especially against the background of space heating using clean energy.

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