Development of a Standards, Testing, and Certification Program to Support the Domestic Solar Water Heating Market in China

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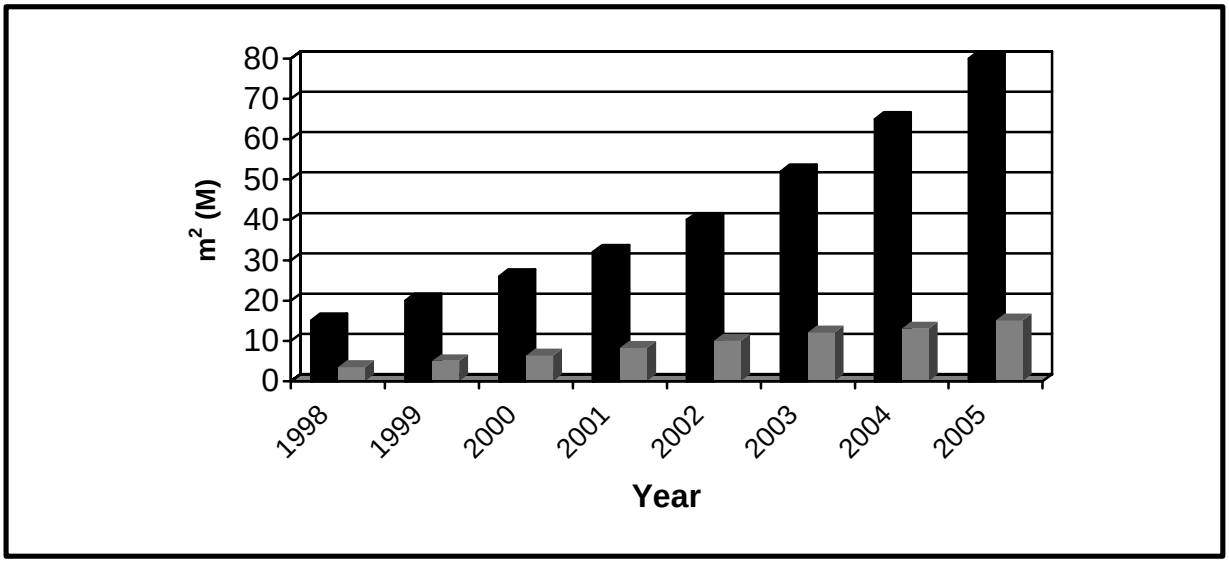
- ***Abstract:*** *China is the world's largest market for solar water heaters, having an estimated cumulative installed capacity of 80 million m^2 of flat plate and all-glass evacuated tube collector systems at the end of 2005. In order to help create the conditions that can insure the continued growth and expansion of this market, the United Nations Development Programme and the Global Environment Facility have cooperated with the National Development and Reform Commission to support the National Solar Water Heating Standards, Testing, and Certification Program in China for industrial products. Acitivites in this program include the development of new standards to complete the foundation for a testing program, the establishment of three national solar water heating test centers to perform testing for the industry, and the development of a national certification and product labeling program to inspire consumer confidence in solar water heating products. Currently, 17 of China's leading solar water heating manufacturers have passed certification for participation in the new Gold Star product labeling system. The status, current development, and future trends for China's solar water heating markets will also be reviewed.*

Key words: *Solar water heaters; standards; certification; testing*

1. Introduction

China is the world's largest market for solar water heaters, having an estimated cumulative installed capacity of 75 [1] to 80 [2] million m^2 of flat plate and all-glass evacuated tube collector systems at the end of 2005. Compared with a world total installed capacity of glazed flat plate and evacuated tube collector systems of 125 million m^2, equivalent to 88 GWth in 2005 [2], about 60% of the world's solar water heating systems are installed in China. The annual manufacturing production and cumulative installed capacity for solar water heaters for the past eight years is shown in Figure 1.

Figure 1: Annual Production and Cumulative Installed Capacity of SWH Systems in China (Million m^2)



Globally, the cumulative installed capacity of solar water heating systems grew 14% from 110 million m^2 in 2004 (77 GWth) to 125 million m^2 in 2005 (88 GWth), excluding unglazed collectors used for applications such as heating swimming pools. World annual production grew from 17 million m^2 per year in 2004 to 19 million m^2 per year in 2005 [2].

Over the past five years the production of solar water heating systems in China almost doubled from 8.2 million m^2 in 2001 to 15 million m^2 in 2005 [1], and about 80% of the new global capacity added in 2005 was produced in China [2]. China's annual production of solar water heating systems in 2005 was more than seven times the 2 million m^2 produced in Europe [3]. Sales of solar water heating systems in China in 2005 were valued at about 20 billion RMB (Renminbi, current exchange rate: 1 USD=8.0 RMB) in an industry that employs more than 500,000 people.

1.1. Current Status of Solar Water Heating Market in China

Although there are over 1000 companies that manufacture and distribute solar water heating products in China, about 100 companies can be considered competitive. The top 10 companies (with annual sales of more than 100 million RMB) have a combined market share of over 20%. There are an additional 20 companies having annual sales of more than 50 million but less than 100 million RMB per year [4]. In 2005, 90% of the solar water heating systems produced in China were glass vacuum tube products produced by 61 enterprises. The remaining systems were flat plate systems, mostly of the thermosiphon type. There was a small contribution from other product types [1].

An analysis of market penetration in 2004 in terms of installed capacity of solar water systems per 100,000 inhabitants shows that although China is the world's largest market, the level of penetration is still small. Countries with the highest per capita installed area of solar water systems in terms of m^2/100,000 population include Cyprus (90,000), Israel (74,280), Greece (27,140) and Austria (26,860). Larger markets in Germany, accounting for almost one-half of the solar water heating system installations in Europe in 2005 (0.95 million m^2), and in China had smaller market penetrations of 6,910 and 4,760 m^2 per 100,000 population, respectively, representing considerable potential for future market expansion [3].

Ninety per cent of solar water heating products in China are installed in the urban environment, 30% in large cities and 60% in suburban areas and smaller cities [4]. Typically, solar water heating systems are installed on the rooftops of multi-story residential and commercial buildings. Therefore, China is not only the world's largest solar water heating market, but also has largest base of solar water systems installed in urban applications.

1.2. Challenges and Future Development

If 25% of the households in China used solar water heaters, the industry estimates a potential market of 270 million m^2 [4]. Given this potential and based on scenarios for continued aggressive expansion of the solar water heating market, the National Development and Reform Commission has established targets for cumulative installed solar water heating capacity in China of 150 million m^2 by 2010 and 300 million m^2 by 2020. This level of development represents an annual average growth rate of about 10%.

In order to achieve the national targets, the continued strong growth of the market in China must address several issues. With more than 1000 companies manufacturing and distributing solar water heating products in China, quality control and the existence of poor quality products are major issues, ultimately impacting customer confidence and acceptance of products in the marketplace. In addition, several large municipalities in China have exhibited a resistance to the continued present deployment methods for solar water heating products on buildings for aesthetic and safety reasons.

Consequently, in China there has been a renewed emphasis on the development of new standards for solar water heating systems and establishing a national testing and certification system for solar water heating products. There is also an emerging interest in developing building integrated solar technologies, demonstration projects, and building codes to influence the direction of technology deployment in China. One of the provisions of the implementing regulations for China's Renewable Energy Law, which was passed in February 2005 by the National Peoples' Congress, is a mandate for the Ministry of Construction to encourage building integration of solar water heating systems and the development of standards and building codes to promote this objective.

▪ 2. National SWH Standards, Testing, and Certification Program

In 2001, the Chinese State Economic and Trade Commission initiated support to develop a National Solar Water Heating Standards, Testing and Certification Program, which was subsequently supported by the National Development and Reform Commission in China after government restructuring in 2003. The United Nations Development Programme and the Global Environment Facility have been partners with the Chinese Government in this development process [5].

The program consists of three major components: 1) developing new standards for solar water heating product development and testing, 2) establishing a network of national solar water heating testing centers, and 3) establishing a certification program for solar water heating products.

2.1. Development of New Standards for the Solar Water Heating Industry

During 2001 through 2003, four new national standards for the solar water heating industry, as shown in Table 2, were drafted under the direction of the Chinese National Institute for Standardization. These standards borrowed heavily from international ISO and European National (EN) standards to establish the specifications and procedures for product testing for solar water heating system and component performance tests for flat plate and vacuum tube systems, and for acceptance tests for reliability. In addition, three new industry standards were

prepared governing product development and installation and service issues, which fell outside the scope of the NDRC/UNDP/GEF Project. Together with 10 previously existing standards, the new standards complete the overall framework for testing that can serve as the basis for product certification [6].

Table 2: New National and Industry Standards for the SWH Industry

National Standards	Content
GB/T 18708-2002	Test methods for thermal performance of domestic solar water heating systems
GB/T 18713-2002	Solar water heating systems -Design, installation and engineering acceptance
GB/T 19141-2003	Specifications for solar water heating systems
GB/T 18974-2003	Indoor test methods for the thermal performance of solar collectors
Industry Standards	Content
NY/T 513-2002	Technical standards for auxiliary electric heating devices for solar water heaters
NY/T 514-2002	Technical standards for water tanks for domestic solar water heaters
NY/T 651-2002	Technical standards for installation and service for domestic solar water heaters

GB/T-18708-2002 specifies the procedures and requirements for testing the thermal performance of domestic solar water heating systems without auxiliary heat, including daily thermal performance of the system and heat loss from the storage tank. The standard defines multi-day test procedures approximating test methods used in ISO 9459-2, but is at an intermediate stage with respect to the ISO standard and cannot yet be used for predicting long term performance.

GB/T-18713-2002 specifies procedures to follow for designing systems, system requirements, system construction and installation, and system commissioning and acceptance, and is applicable to different circulation modes for household solar hot water systems with storage tank capacities within specified limits. This standard has been very influential in developing a recent new national standard, GB/T 50364-2005 "Technical Code for Solar Water Heating System of Civil Buildings," that is used to support the development of building-integrated solar water heating systems.

GB/T-19141-2003 specifies technical requirements (general requirements, component requirements, and specifications for safety devices), test methods, documentation procedures, inspection rules, packaging and transportation of domestic solar water heating systems. The standard specifies test methods for thermal performance, durability, and reliability testing. It includes specifications for daily energy output thermal performance requirements based on a one-day test procedure, which serves as the basis of the current pass/fail certification and product labeling system. It is likely that this standard will be modified in the future to allow for multiple quality levels, incorporate performance prediction for long-term energy output, and facilitate conversion of the product labeling system to an energy labeling system.

GB/T-18974-2003 specifies indoor test methods, requirements and procedures for determining steady state and quasi-steady state thermal performance of solar collectors, including measurements for environmental and collector parameters. It is applicable to glazed flat-plate solar collectors and evacuated tube collectors that are not concentrating systems or integrated storage and collector systems.

2.2: National Solar Water Heating Testing Centers

In addition to the standards development, the Government of China authorized the formation of three National Solar Water Heating Testing Centers in 2002, which have been established at institutes that are geographically distributed throughout China (Table 3). The NDRC/UNDP/GEF Project has provided support to these centers

during their development stage and the centers are now integrated into a solar water heating system and component testing program based on the national standards framework discussed in the previous section and a national certification program that uses the test results to certify solar water heating products from industry for the national labelling program.

These testing centers have passed (one in final stage) several levels of accreditation, including laboratory accreditation from the Chinese National Accreditation Board for Laboratories (CNAL), receipt of the Metrology Accreditation Certificate, and CAL accreditation for laboratory qualifications. For the purpose of certification of solar water heating products, these three centers will provide testing services for fee to the solar industry as the basis for product certification. One additional testing center has also been accepted for testing solar water heating products in the national certification program, which is in Nanjing, Jiangsu Province, at the Jiangsu Provincial Supervising and Testing Institute for Product Quality and National Quality Inspection Institute.

Table 3: List of National Solar Water Heating Testing Centers in China.

Location	Institution
Kunming, Yunnan Province, southern China	Solar Energy Research Institute, Yunnan Normal University, Yunnan Provincial Quality Supervision and Testing Center for Solar Energy Products
Wuhan, Hubei Province, central China	Hubei Provincial and National Solar Water Heater Supervision and Inspection Center of Product Quality
Beijing, northern China	China Academy of Building Research, National Center for Quality Supervision and Testing of Solar Water Heating Systems

The three National Solar Water Heating Testing Centers have completed a process of: i) procuring equipment and establishing standard testing and laboratory systems that are compatible between the centers, ii) designing and implementing test procedures, iii) participating in a round robin testing program between the centers for inter-laboratory comparison of test procedures and results, and iv) initiating pilot product testing programs merging into operational testing services being supplied to industry. The testing centers were inspected and reviewed by an international and domestic expert team in June 2006.

Standard testing capabilities exist at all of the centers consisting of test systems that were designed by the three centers acting as a team. The testing capabilities consist of the following:

System thermal performance testing is performed using a multiple system test bed with eight test stations, capable of being expanded in the future, for carrying out single-day and multiple-day test procedures for system thermal performance and heat loss coefficient of storage tanks. Most testing is currently done using the single-day test methods, but all laboratories are capable of carrying out multiple-day testing.

Solar collector thermal performance testing is performed using a two-axis tracking test bed capable of testing two units at a time for flat plate and glass evacuated tube collectors to determine the steady state efficiency, effective thermal capacity, time constant, incident angle modifier, average heat loss coefficient, and inlet outlet pressure drop of collectors.

System qualification testing for the durability and reliability of solar water heating systems employs a rig to perform tests for freeze resistance, pressure resistance, water contamination, lightning protection, mechanical strength, reverse flow protection, and electrical safety tests for mechanical and environmental stressing.

Collector qualification testing is performed in a two loop test bed using one loop to test for internal thermal shock and pressure resistance, and the other loop for external shock and rain penetration tests.

All-glass evacuated collector tube thermal and qualification testing is performed to measure the solar exposure parameter, stagnation solar irradiation, and average heat loss coefficient of single tubes, as well as to perform vacuum performance, thermal shock, pressure resistance, and mechanical impact testing of single tubes.

Material testing capabilities include measurement of the optical and thermal properties of solar materials.

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2.3: National Certification and "Gold Star" Product Labelling Program

In order to increase consumer confidence in the solar water heating industry, China has established a national product certification and labelling program for solar water heating products. Since 2003 the program has been carried out by the China Jianheng (General) Certification Center in Beijing that performs the functions of a National Solar Water Heating Certification Center. The Center is responsible for the overall quality control and coordination system among the National Solar Water Heating Testing Centers, accepting and reviewing test reports, and issuing certificates and labels to manufacturers for product certification.

During the establishment of the national program a series of actions were coordinated by the China Jianheng Certification Center, including as a first step establishing an overall steering committee and an Expert Working Group consisting of leading solar water heating experts and industry representatives in China. The initial phase of program development included: development of unified test procedures and reporting requirements for test reports; preparation of the "Implementation Rules for Solar Water Heater Certification" in coordination with the government, the solar water heating industry and the National Testing Centers; completing the solar water heating certificate and label design program and issuing rules for using labels, and finalizing guidelines for certification.

The Jianheng Center developed the "Gold Star" product certificate and labelling system on a pass/fail basis using criteria established in the Implementation Rules for Solar Water Heating Certification. During 2005, a pilot program was executed for 17 leading solar water heating manufacturers recommended by the Chinese Renewable Energy Industries Association and the China Thermal Application Association. The pilot program was a rigorous incremental process of working with the industry to conduct a series of type tests and factory inspections, implementation of factory quality control procedures, and meeting product selection regulations. The iterative process was designed not only to help manufacturers acclimate to the new program, but also to work out deficiencies in the design and execution of the program.

During March 2006, the China Jianheng Certification Center conducted a press conference and workshop to introduce the new certification program to industry and the general public. A promotion campaign was conducted that included wide media coverage, during which the first 17 solar water heating manufacturers to qualify for the right to display the Gold Star label on their products were introduced to the public in a formal ceremony. Subsequently, the China Jianheng Certification Center has conducted a broad promotion campaign to kick start the labelling program.

Currently, the certification and labelling program is based on a pass/fail system similar in concept to the Solar Keymark program for certification in Europe. The China Jianheng Certification Center, however, envisions that the program will evolve to an energy labelling system in the future.

▪ 3. Building Integrated Solar Water Heating Systems

One of the significant trends in China is the strong interest in developing building integrated solar water heating technologies to promote the acceptance of the solar water systems in China's cities. The United Nations Foundation is one organization working in partnership with the Chinese National Development and Reform Commission and the Ministry of Construction to build capacity to support this development trend. The effort involves working with Chinese architects, building developers, the solar water heating industry, municipal governments, and the solar expert community.

Current activities include promotion of several pilot projects that have been constructed in several cities in China. The initial experience of the Chinese industry covers a range of applications, from residential to commercial buildings, single-family homes to large integrated systems. In addition, the Ministry of Construction has supported Chinese expert teams to prepare a series of guidebooks for industry use, including the publication "Integration of Solar Heating into Residential Buildings: International Practices and Perspectives in China." [7]. The Ministry of Construction has also published the *Technical Code for Solar Water Heating Systems in Civil Buildings* that updates design, installation, and acceptance codes for solar water heating systems in civil buildings in early 2006 [8].

▪ 4. Policy Development

Nominal strategic planning targets established by the National Development and Reform Commission call for 150 million m^2 in 2010 and 300 million m^2 in 2020 of cumulative installed capacity of solar water heating systems in China. One action in support of achieving these targets is the development of the *Renewable Energy Law*, which was passed by the National Peoples' Congress in 2005.

Some of the provisions associated with the law and incorporated into the national strategic planning of the NDRC for renewables include i) a revised target of 16% of primary energy from renewables by 2020, ii) requiring national solar resource assessment and inventories, and iii) requiring building access for solar water heating systems. The latter provision is the responsibility of the Ministry of Construction.

▪ Conclusions

China has the world's largest commercial market for solar water heating systems which continues to expand and exhibit robust growth. The market is evolving with the introduction of new technologies, consolidation of the manufacturing base with high growth rates for the leading manufacturers, and trends toward new applications, such as building integrated systems. Regulating this market is challenging but necessary in order to increase product quality and consumer confidence in the industry and the marketplace. The Chinese Government has established the National Solar Water Heating Standards, Testing and Certification Program that has been successfully implemented to develop the Gold Star certification and labeling system for solar water heating products. The national program is still in an early stage of development and is designed to evolve and grow to meet the ongoing needs of the solar water heating industry. The long term strategic planning efforts of the Chinese Government incorporate solar water heating technologies as a major contributor to long term targets for renewable energy development, and will continue to provide support for this market sector.

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