SURVEY OF LARGE-SCALE SOLAR WATER HEATERS INSTALLED IN TAIWAN

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ABSTRACT

Almost all the solar collectors installed in Taiwan were used for production of hot water for homeowners (residential systems), in which the area of solar collectors is less than 10 square meters. From 2001 to 2006, there were only 39 large-scale systems (defined as the area of solar collectors being over 100 m^2) installed. Their utilization purposes are for rooming house (dormitory), swimming pool, restaurant, and manufacturing process. A comprehensive survey of those large-scale solar water heaters was conducted in 2006. The objectives of the survey were to asses the systems' performance and to have the feedback from the individual users. It is found that lack of experience in system design and maintenance are the key factors for reliable operation of a system. For further promotion of large-scale solar water heaters in Taiwan, a more compressive program on a system design for manufacturing process should be conducted.

1. SOLAR WATER HEATERS IN TAIWAN

Among various forms of renewable energy, solar thermal energy is the most wide spread use in many countries [1, 2, 3]. Taiwan's climate is subtropical, which is an ideal location to take advantage of solar thermal energy technologies [4]. Use of solar water heaters (SWHs) in Taiwan began in 1978. However, the number of SWHs installed was quite limited because of higher capital cost compared with the conventional ones, e.g. LNG or natural gas water heaters. To the development of indigenous alternative and renewable energy resources in Taiwan, the subsidy programs (1986-1991, 2000-present) have been established for solar water heaters. In Fig. 1, it can be seen that the subsidy program were obviously critical for promotion of SWHs [5]. In 2001, there were only about thirteen thousand SWHs installed. With the subsidy program, the SWHs installed were up to twenty-three thousand units in 2006. The area of solar collector (SC) installed also increases from 70,000 to 115,000 square meters per year.

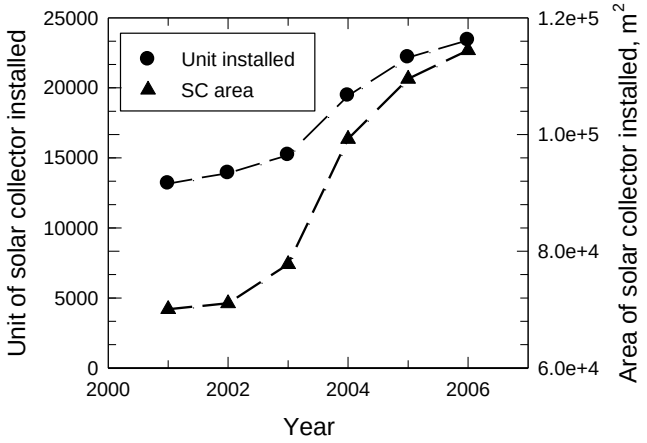

Fig. 1: SWHs installed from 2001 to 2006

A general survey of SWHs' users indicated that most solar water heaters were mainly used by the domestic sector for hot water production [5]. In terms of area of solar collector, the SWHs were categorized into to five groups as shown in Table 1. There were over 97% SWHs with the area of solar collector less than 10 square meters, which is considered as the residential systems. It is also noted that the units of residential system increase within the current subsidy program, but not for larger scale systems. There are less than ten SWHs with area of solar collector over 100 square meters each year. In addition, Chang et al. [6, 7] inferred

that the current subsidy program might is no longer a key factor in promoting the market of SWHs in Taiwan. As a results, the government will need to develop new strategies, and promotion of large-scale SWHs (or commercial systems) should be addressed. For the present study, a comprehensive survey for the users of large-scale SWHs was conducted. This is considered to be crucial for promotion of large-scale SWHs in the near future.

TABLE 1: UNITS OF SWHs

collector year	<5 m^2	5-10	10-50	50-100	>100	Total
2001	6,583	5,780	292	26	9	12,690
2002	8,050	6,260	361	16	4	14,691
2003	9,060	7,027	430	27	4	16,548
2004	11,890	9,300	409	24	8	21,661
2005	12,800	9,363	391	20	5	22,579
2006	14,111	9,806	363	16	9	24,305

2. LARGE-SCALE SWHs

According to ``Guidelines for promoting Solar Hot-Water System ‘’, the end users of SWHs must file application form before purchase of a system. For large-scale systems, an extra layout of the system is required. A review committee then evaluates the proposal based on the system design criteria, e.g. local weather conditions (sunshine hours, insolation and temperature), thermal efficiency of solar collector, piping (thermal insulation), storage tanks and auxiliary equipment. The comments from reviewers will assist the installer to revise the system design. As seen in Table 1, there are 39 large-scale SWHs installed by twenty installers from 2001 to 2006. Among those installers, thirteen of them only installed one large-scale system during this period. It appears that most installers lack experience in system design.

Those large-scale SWHs were used for rooming house (dormitory), swimming pool, manufacturing process and restaurant. The basic data of some SWHs are shown in Table 2. In addition, it can be seen that thirty-two SWHs was built for sanitary water heating and five for swimming pool. Only two systems were designed for manufacturing process and restaurant, Fig. 2. In terms of type of solar collector, Fig. 3, thirty five systems used flat-plate type. Only four systems adopted vacuum-tube (Fig. 4) or other type. Furthermore, two out of five SWHs for swimming pool adopted a special kind of solar collector. This unglazed flat-plate solar collector is cheaper in cost and less thermal efficiency in heat collection. As shown in Fig. 5, this special kind of solar collectors were stuck to the roof. This is considered to have less impact by strong wing loading during the typhoon season. However, it is noted that Taiwan is situated between latitude 22 and 25 degrees North. The tilt angle of solar collector is not the same as common practice, which might affect the thermal efficiency of the system.

TABLE 2: BASIC DATA OF SOME SWHs

Location	Purpose	SC type	SC area, m^2
College	dormitory	Flat	308
Glass Ltd.	Manufacturing	Flat	386
College	Swimming pool	unglazed	1,320
Electric Ltd.	Rooming house	Vacuum tube	102
Restaurant	Dish washer	Flat	206

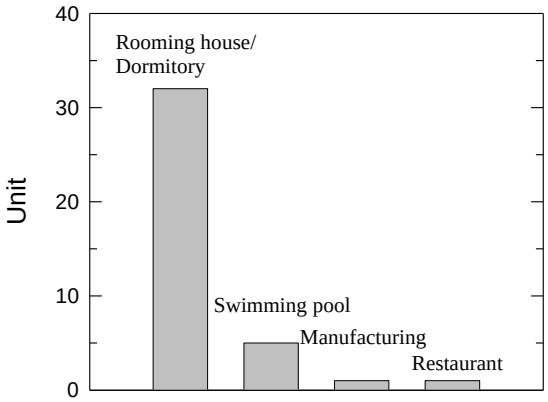

Fig.2: Purpose of SWHs

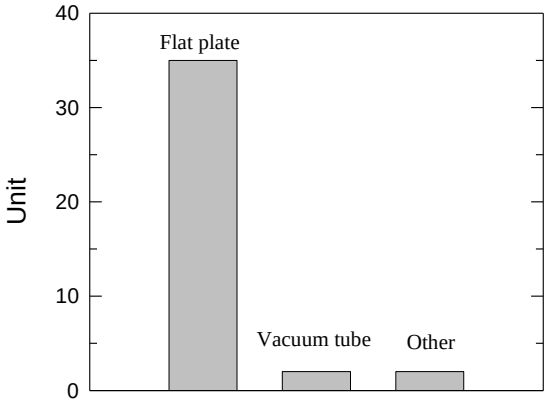

Fig. 3: Type of solar collector

3. OPERATION OF SWHs

During the lifetime of a SWH, the benefit is associated with the system operation and durability change. Thus a comprehensive survey in 2006 was conducted to evaluate the performance of large-scale SWHs installed. Several key issues were addressed, which included

(1) Reliability (solar collector and auxiliary system)
(2) Efficiency
(3) Maintenance (cost and staff)

It is known that SWHs are the least reliable water heater, which is strongly affected by duration of local sunshine hours, in comparison with other water heaters (electric heating, kerosene heater or LPG heater). However, more than 95% residential systems in Taiwan had an electrical boost element, which could be capable of safely supplying hot water to the households over day no matter what weather is. For most large-scale SWHs (dormitory and rooming house), SWH is integrated with kerosene heater as an auxiliary hot water supply. Furthermore, the proper design of a SWH for swimming pool is related to the local temperatures at different seasons. Since Taiwan's climate is subtropical, overheating is the major concern in summer.

An indication by evaluaing SWH's efficiency is the cost of fuel. As mentioned above, most SWHs in the dormitories integrated the kerosene heater and SWH. Regulation of hot water supply was set, and reduction in cost of fuel up to 50% was reported. However, there was higher hot water consumption than expected for one system (dormitory), which has been abandoned few years ago. The electric heating replaced the old system, and the students were charged individually in accordance with the consumed electricity. This dropped hot water consumption significantly.

Maintenance is the key issue for long-term operation of large-scale SWHs. In general, most systems are not well maintained due to lack of maintenance or unqualified maintaining staff. Leakage of gate valves and sealing deterioration were frequently reported. Thermal insulation degradation is in common. For the system near the beach, the corrosion due to salty air can be seen in Fig. 6, e.g. high absorber paint degradation and corrosion of supporting structure. In addition, some broken glasses were reported, Fig. 7. This might be related to the impact of debris during the typhoon invasion. Finally, the dust on the top glasses would reduce the thermal efficiency of solar collectors. Regular maintenance is required

4. CONCLUSIONS

The current subsidy has a great impact on the popularity of SWHs in Taiwan. However, the large-scale SWHs installed were still limited, and some new strategies should be enforced. It is also noted that most installers are lack of experience in system design of large-scale SWH. In particular, overheating in summer time is one of the major concerns in designing a system for swimming pool. A comprehensive guideline on system design should be addressed in the near future. The present survey also indicated the influences of salty air and rain penetration on supporting structure and casing as well as the deterioration of absorber paint and sealing materials. The maintenance staffs should be well trained, and the regular and professional maintenance is required for reliable operation of the system. Finally, most large-scale SWHs installed were for dormitory or rooming house. In terms of efficiency, the systems for manufacturing process will result in the most benefit in comparison with other application. Further efforts should be done.

5. ACKNOWLEDGMENTS

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Fig. 4: SWH-Vacuum-Tube Type

Fig. 5: SWH-Unglazed Flat-Plate Type

Fig. 6: Corrosion due to Salty Air

Fig. 7: Broken Glasses and Dust Accumulation