

# SOME FACTORS ON PROMOTING SOLAR WATER HEATERS IN TAIWAN

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Solar water heaters (SWHs) have been commercialized during the last two decades in Taiwan. The government initiated the incentive program during 1986-1991. The industry of SWH expanded very quickly and reached about 60,000 square meters in the area of installed solar collectors per year. However, the installation of SWH slowed down during 1995-1999. To further prompt the application of solar thermal energy, the government initiated another incentive program from 2000 to the present. This created an economic incentive for the end users. The area of installed solar collector is up to 100,000 square meters each year, and the total area of installed solar collectors in Taiwan is more than 1.3 million square meters in 2005. This incentive programs by the government have a drastic effect on the popularization of SWHs. The data of SWH's users also shows that most of SWHs are mainly used by the domestic sector for hot water production (about 97 %). To further promote SWHs during this current incentive program period, several factors are addressed. The cost of SWHs, energy price, climatic condition (e.g. typhoon), urbanization and building type are considered to be associated the potential market of SWHs in Taiwan.

**Key words:** solar water heater, incentive program, urbanization, climatic condition

## INTRODUCTION

The Taiwan's total energy consumption has grown greatly over the past two decades, which is an average annual growth of 6.5%. However, Taiwan is densely populated with limited natural resources. The ratio of indigenous energy (about 2.4 million kiloliters of oil equivalent, MKLOE) to total primary energy supply (about 134.1 MKLOE) is only about 1.79% in 2004. The value of energy imports was US\$20.56 billion [1]. To comply with the needs of the government's continuing economic construction projects and the changes in the international economic and energy situations, the Energy Policy of the Taiwan Area was established. It is expected that the renewable energy will share 3% of primary energy supply in 2020.

The Bureau of Energy, Ministry of Economic Affairs (MOEA) of Republic of China (ROC) has promoted the research and development of renewable energy in last two decades. Taiwan's climate is subtropical, and is ideally located to take advantage of solar thermal energy technology. Manufacture of SWHs began in 1978. However, the number of installed SWH was quite limited due to higher selling price compared with the conventional ones, e.g. gaseous or electrical water heaters. To the development of indigenous alternative and renewable energy resources, the government initiated a six-year incentive program (1986-1991) to prompt the installation of SWHs. The industry of SWHs, which were mainly for hot water production by the domestic sector, expanded very quickly. Furthermore, the installation of SWHs slowed down during 1995-1999. To further prompt the application of solar thermal energy, the government initiated another incentive program from June 2000 to present. It was found that the subsidy programs were obviously critical for the promotion and installation of SWHs. The installed area of solar collectors increased significantly, and was over 1.3 million square meters up to 2005. It is also noted that the Taiwan's government also focused on dissemination to the end users and educates them on the benefits of renewable energy technologies. This is critical to the

widespread deployment of SWHs during the past decades.

The present paper tends to address the present status and some factors in promoting SWHs in Taiwan. A comprehensive survey of the households installing SWHs in 2001-2005 was reported, and the influence of climatic condition, urbanization, and building type of housing are addressed.

## SWHs IN TAIWAN

In Taiwan, the incentive program is critical for the promotion of SWHs, Fig. 1. Based on the annual data of Energy Research Laboratories of Industrial Technology and Research Institute (ERL/ITRI) since 1987, the installed area of solar collector increased from 5,000 square meters to 60,000 square meters per year during the first period of incentive program (1986-1991). The second incentive program (2000-present) also shows a strong impact on the installation of SWHs. The installed area of solar collectors was 56,500 square meters in 1999, and increased to be about 110,000 square meters in 2005. The average annual growth during the second incentive program is about 8.8%.

There are two major types of solar collectors in Taiwan. The flat-plate type solar collectors with metal absorbers and glass cover are widely used to transform solar energy into heat. They represent 90.6%-94.9% market share within 2001 and 2005. The remaining 5.1%-9.1% comes from the vacuum-tube type solar collectors. Moreover, 97.2%-98.0% of installed solar collectors were used for production of hot water in domestic sector, in which mainly the area of solar collector is less than 10 square meters. Limited commercial systems (over 100 square meters in the area of solar collector, such for dormitory, hotel or hospital) were installed, and this is the portion which must be further promoted. The remaining SWHs are for the showering of rooming house, swimming pool heater, and the manufacturing process [2].

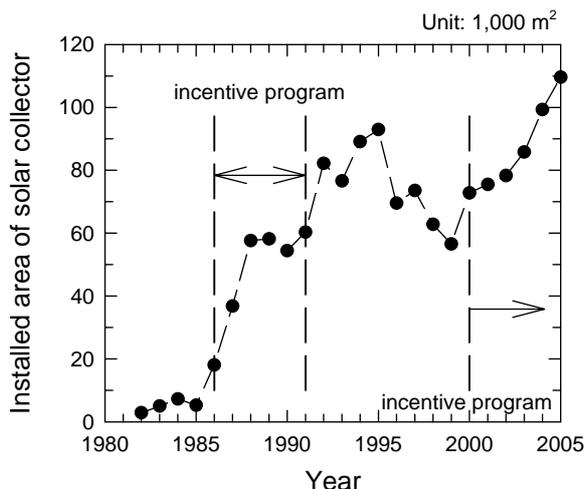


Figure 1 Installed area of solar collector

### FACTORS IN PROMOTING SWHS

Taiwan is situated between latitude 22 and 25 degrees North, which is ideally located to take advantage of solar thermal energy technologies. The average daily global solar insolation is about 280 Langley (3.25 kWh/m<sup>2</sup>) in the north and 400 Langley (4.64 kWh/m<sup>2</sup>) in the south [3]. This is essentially related to the feedback period at different districts. During the second incentive program, the statistics of installed area of solar collector per thousand households are shown in Fig. 2. It can be seen that installation of SWHS is mainly in the west and southern districts. The southern Taiwan district has the most favorable sunlight conditions, while residential and commercial sectors installed SWHS with a longer annual sunshine duration and higher average solar intensity. In the west Taiwan district, higher installation rate of SWHS was mainly due to the re-construction project after the 921 severe earthquake in 1999. The SWH became a standard feature for a lot of newly built houses. The installed area of SWHS in the northern Taiwan district is considerably lower than those in the west and southern Taiwan districts.

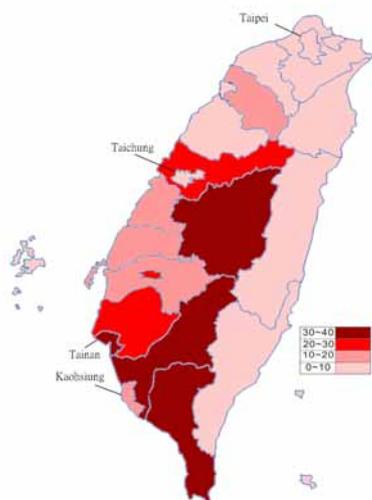


Figure 2 Distribution of installed area of solar collector per thousand household

In Fig. 2, it also can be seen that the solar insolation might not be the major key factor for end users to install SWHS. For instance, the cost of SWHS is sufficiently higher than popular gaseous water heaters in Taiwan. The home owners might consider the extra expenditure in the purchase of the system. This is related to the disposal income of each household. The energy price, such as electricity and natural gas, is another concern. This is associated with the feedback period. In addition, almost all SWHS were installed on the flat roof of buildings. Two issues are of major concerns. First, Taiwan is situated in the prevalent typhoon track in the northwestern Pacific. The safety of SWHS due to severe wind load during the typhoon season should be addressed. Further, only the cottage or duplex houses are more probable of installing SWHS on the flat roof of buildings. However, Taiwan is densely populated. In main metropolitan and sub-metropolitan, apartment and congregate housing are the major types of housing. Limited residential SWHS is expected.

### Cost of SWHS

The economical feasibility of SWHS is mainly determined by their initial cost and long term efficiency. Higher cost of SWHS compared with conventional ones is one of the factors for the end users to install the systems. This would essentially be associated with the income levels of each household. If the cost of SWHS is less than a specific fraction of current receipts of each household, it is more probable of investing in the purchase of SWHS. The average family income in Taiwan, including current receipts and disposal income, is shown in Fig. 3 [3]. In early eighties, limited purchase of SWHS is considered to be associated to lower average family income. During the first incentive program (1986-1991), the installed area of solar collector increased significantly. This would partially correspond to the rapid economic growth and a subsequent increase in the current receipts and disposal income of each household. More households can afford to purchase SWHS. Furthermore, the installation of SWHS slowed down within 1995-1999 [2]. This might be due to the flattened level of average family income and the end of the first incentive program. The end users might have less motivation to purchase SWHS.

### Energy price

The gaseous or electrical water heaters are popular in Taiwan. Other than the hardware cost, the cost of fuel counts the most of overall cost for both water heaters. Thus based on the consideration of cost-to-benefit ratio, the monetary benefits accrued to the end users would depend on the amount and cost of electricity or fuel saved through the use of SWHS. The energy price indexes from 1980 to present are shown in Fig. 4 [2]. It is known that the abundant supply of electricity is the foundation of national economic development. As a stated-owned public utility, Taiwan power company (Taipower) has to fulfill the governmental energy policy. Although the international energy price has been on a trend of increase, variation of electricity rates during the past 25 years is rather limited [4]. This is considered not to worsen the impact of people's livelihood. However, lower electricity rates

correspond to a longer payback period to the end users of SWHs. For the gaseous water heaters, there is a drastic increase in the price of natural gas during the past few years. This results in increased monetary worth of annual fuel savings. This might provide stronger motivation for the end users to purchase SWHs.

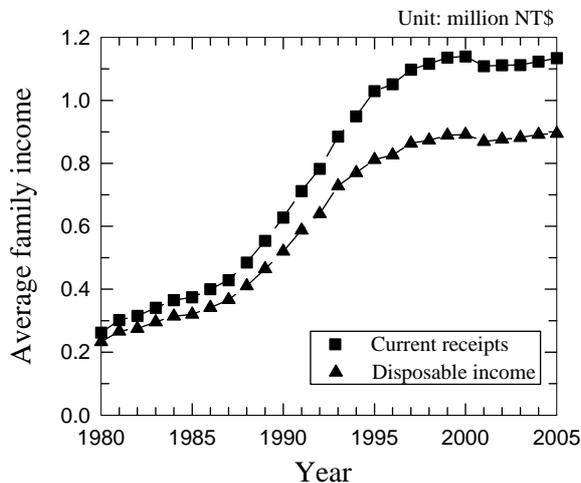


Figure 3 Average family income

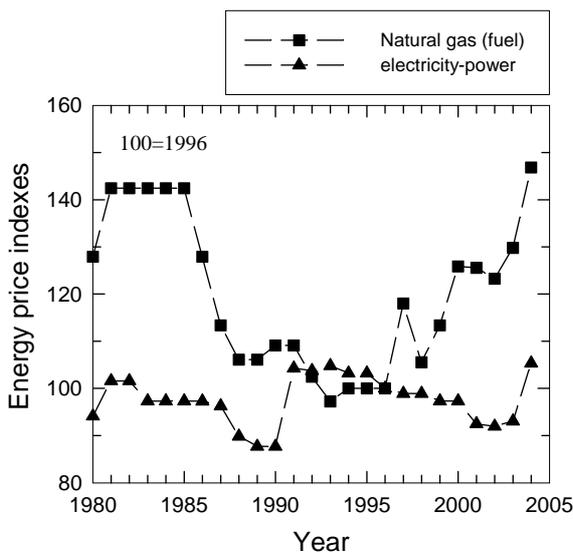


Figure 4 Energy price indexes

### Typhoon

Typhoons are among the most costly natural hazards to impact residential construction, which includes SWHs. In summer and late summer, tens of typhoons may occur over the western North Pacific and South China Sea each year, and some affect the Taiwan area. Historical record is shown in Table 1 [5]. There were 380 tropical storms/typhoons invading Taiwan from 1897 to 2004, in which three to four typhoons hit Taiwan each year. In terms of their tracking patterns, the occurring number and frequency of the nine groups of invading typhoons is shown in Fig. 5. It can be seen that the eastern Taiwan is mostly subject to the impact of typhoons. The wind strength is attenuated over the west due to the high

mountain area in Central Range. Thus as shown in Fig. 1, the installed area of solar collector in the east is considerably lower than that in the west.

Taiwan experienced several severe typhoon hits in 2005. For instance, Haitang developed as a tropical depression about northwest of Guam on July 12. Headed southwest at first and then turned northwestwards. As Haitang approached Taiwan, winds of hurricane intensity (Beaufort scale 16, 55 m/s) struck the eastern Taiwan in the early morning of July 18. The eye of typhoon was over the west coast before midnight and headed northwest into Mainland China. Moving further inland, Haitang became an area of low pressure on July 20. During the passage of Haitang over Taiwan, numerous damaged SWHs were reported. Thus the impact of typhoons could be one of the major concerns for the home owners to install SWHs in the eastern Taiwan. To resolve this issue, Chung et al. [6, 7] studied the aerodynamics characteristics of a commercial SWH. Strong pressure load and uplift force on the solar collector result in the broken glass cover and damaged frame of the system. Further studies on reduction of pressure load and uplift force of the solar collector panel should be conducted.

Table 1 Historical record of tropical storms/typhoons

Beaufort scale	Wind speed (m/s)	No. of typhoon invading Taiwan (1897-2004)
8-11	17.2-32.6	108
12-15	32.7-50.9	196
Over 16	Over 51	76

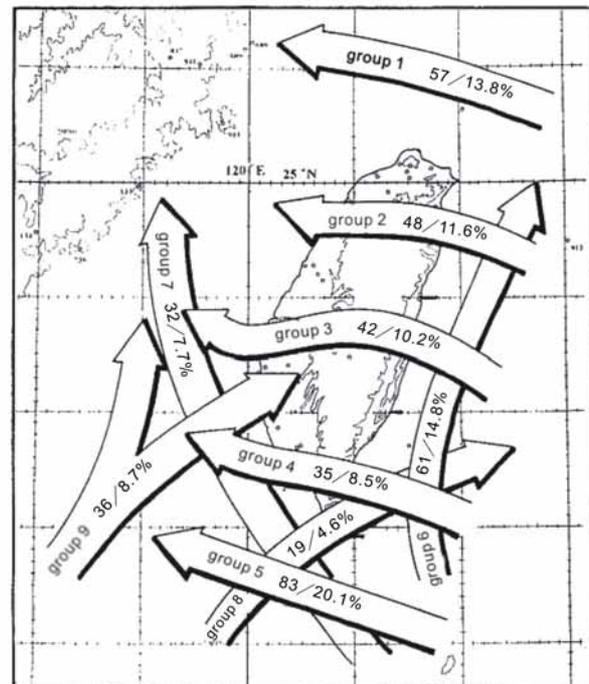


Figure 5 Track number and frequency of typhoons [4]

## Type of buildings

The potential number of households using SWHs also depends on the availability of space for installation. Chang et al. [1] indicated that over 90% SWHs in Taiwan were installed on the flat roof of housing. Since the composition of housing in urban and rural communities is essentially not the same, this affects the popularization of SWHs in different districts. According to Directorate General of Budget Accounting and Statistics (DGBAS, ROC), the urban community includes main-metropolitan (more than one million residents) and sub-metropolitan (0.3 to 1 million residents). As shown in Fig. 1, the installed area of solar collector per thousand households in the Taipei main metropolitan is sufficiently lower than that in other districts. According to the statistics of Construction and Planning Agency, Ministry of Interior Affairs [8], apartment and congregate housing are the major types of housing (almost 80%). The government may need to take the other strategy to promote the installation of SWHs. In other districts, over 60% housing are cottage or duplex house which are more probable of installing SWH on the flat roof.

Completion of housing construction is another concern. Chang et al. [9] indicated that two thirds of households with SWH are considered to be new construction. The completion of housing construction ranges between 1 to 3 years. This implies that the popularization of SWH might be strongly coupled with the status of new construction. From 1988 to 1999, the installed area of solar collectors is coupled with the total floor area or floor area of housing and store with housing reasonably well, Fig. 6. The ratio increases after 2000, which is associated with the second period of incentive program. It is expected that the potential market of SWHs in Taiwan will be coupled with the status of new construction after the end of present incentive program.

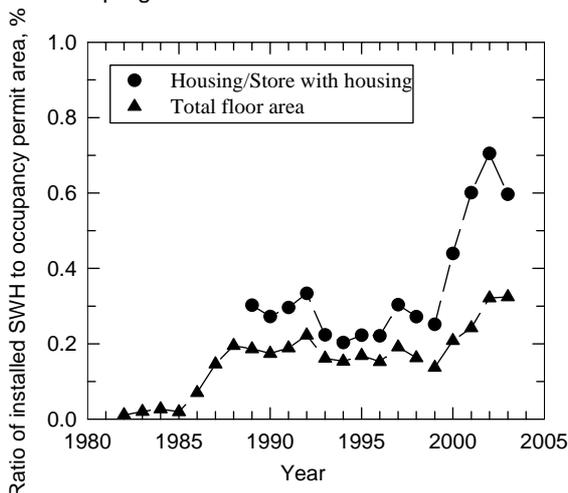


Figure 6 Installed area of solar collectors to floor area of new construction [8]

## CONCLUSIONS

Although solar water heaters have been the mature product in Taiwan during the past decades, the population of residential systems is still less than 4%. Due to strict

regulation of greenhouse gases and higher fuel cost in the near future, further efforts should be done by the government to prompt the installation of SWHs. This might include the measures, support mechanisms and public awareness of renewable energy. In addition, the impact of typhoon is of great concerns in the eastern Taiwan. Further study is required to investigate the aerodynamic characteristics of SWHs in terms of safety concerns.

## ACKNOWLEDGEMENT

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