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SUBSIDY PROGRAMS ON DIFFUSION OF SOLAR WATER HEATERS IN TAIWAN

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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 (SWHs). The subsidies create an economic incentive for the end users and have been rather instrumental at the initial stage of each program but lost their significance thereafter. However, the development and use of renewable energy sources and technologies are still vital for the management of energy supply and demand in Taiwan. In expanding the market, Bureau of Energy, Ministry of Economy Affairs (BEMOEA) initiated a revised incentive program in 2009. The subsidy to the end users based on the area of solar collectors installed is 50% more. Further, Kaohsiung city government and Kinman county government announced local incentive programs. An additional subsidy in purchase of a SWH has been granted to the households living in the county or city. Sales expansion is obvious in the local market. In this paper, the efficiency of those subsidy programs on diffusion of solar water heaters in Taiwan is addressed.

Keywords: solar water heater, subsidy, market

INTRODUCTION

Although the intermittent nature of renewable energy resources, they are a sustainable and clean energy asset derived from nature. Other than the net energy saving, the environmental benefits are reduction in the production of air pollutants and release of greenhouse gas into the atmosphere. For the development of indigenous alternative and renewable energy resources, the Taiwanese government initiated subsidy programs on SWHs, solar photovoltaic systems, resource exploration of geothermal power demonstration systems and energy crop green bus projects. A Renewable Energy Development Bill has been decreed to establish a legal environment for renewable energy in 2009. It is expected renewable energy will number 3% of the primary energy supply by the year of 2020 in Taiwan

SWH has been proved to be reliable and economical in cases of hot water production, and is also the most successful story for the development of renewable energy in Taiwan. The accumulated area of solar collectors installed at the end of 20098 reached 1.8977 million square meters. In this context, Taiwan has a lot of experience in the SWHs market. On the other hand, the local market has been growing at a slower pace over the last few years, particularly due to the global economic crisis in 2008. Thus, it is worth the efforts to re-examine the subsidy programs on diffusion of solar water heaters in Taiwan. This information would be useful for the policy makers.The financial incentives have been adopted for SWHs in many countries. In Taiwan, the incentive programs by Bureau of Energy, Ministry of Economic Affairs (BEMOEA) and governments are considered to be the major driving force for market expansion over the last two decades. However, it is necessary to take a look at the relative efficiency of the long-duration incentive programs used. The purpose of this paper aims to examine the effect of subsidy ratio on local market and its possible pitfalls.

SOLAR WATER HEATERS IN TAIWAN

Water heating is one of the major energy consumption for households in Taiwan. It is strongly demanded to use energy-efficient water heaters. In deed, Taiwan lies between latitude 22 and 25 degrees North, The average daily global solar insolation is about 3.25 kWh/m^2 in the north and 4.64 kWh/m^2 in the south. It is quite favorable for the implementation of solar water heaters. However, the area of solar collectors installed was less than 10,000 m^2 per annum from 1981 to 1985, as shown in Fig. 1. This low level of growth was attributed to lower average family income and the higher total installed cost of SWHs in comparison with conventional water heaters Thus a six-year incentive program (1986-1991) was activated by Taiwanese government to encourage the utilization of SWHs. The local market approached 60,000 m^2 in terms of the area of solar collectors installed (A_{SC}) per annum by the end of the program [1]. In the early nineties, both average family disposal income and the consumption expenditures increased significantly. This would be the key factors in market expansion [2]. Further, the Taiwanese government initiated another incentive program for SWHs in 2000 to promote the application of solar thermal energy. A_{SC} was over 100,000 m^2 per annum since 2004 (Chang et al., 2009). Then in terms of service life of 15 years, the operating residential SWHs are estimated to be 0.28 million systems by the end of 2009.

Taiwan began the manufacture of SWHs in 1978 [1], Fig. 1. Over the next seven years, the SWHs penetration in the local market was gradually rising. The area of solar collectors installed was less than 10,000 m^2 per annum. This is attributed to lower average family income in the early eighties and higher installation cost compared with conventional hot water heaters. In order to encourage the utilization of SWHs, the Taiwanese government initiated a six-year incentive program (1986-1991). This built up the standard of application for SWHs, in which more useful energy was collected from a solar collector and lower heat loss were required. The manufacturers of SWHs were also

motivated by this financial incentive. As a result, the local market expanded dramatically (1986-1988), approaching 60,000 m^2 per annum. Over the next three years (1989-1991), the local market was roughly constant. Furthermore, more than 340,000 m^2 of solar collectors were installed through 1992-1995. This would be due to the mature solar thermal technology, and the rapid economic growth and a subsequent increase in the current receipts and disposable income of each household in this period would be the other key factors in market expansion. More households could afford to purchase SWHs [3].

TAIWAN'S SUBSIDY PROGRAMS

As mentioned above, two incentive programs (1986-1991, 2000-present) were initiated by Taiwanese government to promote the utilization of SWHs. From 1986 to 1989, a subsidy (2,000 NTD/m^2 for glazed flat-plate solar collectors and 1,000 NTD/m^2 for unglazed flat-plate solar collectors) was granted in purchase of a SWH, which meet the criteria with regard to thermal performance. The amount of subsidy is half from 1990 to 1991. More than 58,000 SWHs (or A_{SC} = 320,000 m^2) were installed. The key result of this incentive program was also on building up a standard for SWHs with greater efficiency (more useful energy collected from a solar collector and lower heat loss), which also played a key role in developing consumer confidence in SWHs. Further, the average cost of SWHs in terms of A_{SC} decreased significantly (about 35% off) during this incentive program. It could be attributed to economies of scale (sales increase). Taking SR into account, it ranged from 23% to 28% from 1986 to 1989 and dropped below 20% over the next two years

After the decrease of SWH installation between 1995 and 1999, BEMOEA initiated another incentive program (July 2000-present) to foster the application of solar energy. By filling an application form, a subsidy is granted to the end users according to the area and type of solar collectors installed (1,500 NTD/m^2 for glazed flat-plate and evacuated tube solar collectors, and 1,000 NTD/m^2 for unglazed flat-plate solar collectors), which should also meet the thermal performance's criteria as the first incentive program. To encourage the installation of SWHs in remote islands (Kiemen, Penghu, etc), the amount of subsidy is doubled. This incentive program is obviously critical for the promotion of SWHs at the initial stage. The annual A_{SC} doubled from 1999 to 2006 but might lose its significance thereafter [3].

In expanding the market, BEMOEA launched a revised incentive program in 2009. The subsidy to the end users is 50% more. Further, Kiemen county and Kaohsiung city government announced regional incentive programs in 2008. An additional subsidy (grant with the same amount by BEMOEA) in purchase of a SWH was granted to the households living in the Kiemen county (January 2008) or Kaohsiung city (October 2008). With regard to the effectiveness of the regional incentive programs at remote islands, the SWHs deployed and annual A_{SC} in Kiemen and Penghu counties are shown in Fig. 2. It can be seen the market size was very limited in both counties between 2000 and 2007, in which less than 30 systems (or A_{SC} < 100 m^2) were deployed annually. However, the local incentive program by Kiemen county led to exponentially increase SWH sales. The number of SWHs deployed was 113 systems (or A_{SC} = 465 m^2) and 745 systems (or A_{SC} = 4,435 m^2) in 2008 and 2009, respectively. In Kaohsiung city, the expansion of local market increased steadily between 2001 and 2006. The number of SWHs deployed was from 1250 systems (or A_{SC} = 5,464 m^2) in 2001 to 2760 systems (or A_{SC} = 11,560 m^2) in 2006,. The regional incentive program in 2008 provides another driving force for the market expansion. There were over three thousand SWHs deployed (A_{SC} = 14,312 m^2) in 2009.

The annual A_{SC} in Taiwan is also associated with the total installed cost. In Fig. 3, the unit price of a SWH in terms of A_{SC} steadily decreased between 2000 and 2004 and slightly increased over the next two years. In Kaohsiung city, the variation of unit price followed the similar trend. However, price of SWHs increased over 39% between 2006 and 2008. In Kiemen county, it showed the opposite trend between 2000 and 2004, in which the unit price increased over 23%. There was over 58% increase between 2006 and 2008. The number of local qualified installers/dealers could partly explain the peak unit price in 2008. A big drop in 2009 could be inferred to the sales increase (almost ten times in terms of A_{SC}) and more local qualified installers/dealers.

EFFECT OF SUBSIDY RATIO

It is known larger scale SWHs could benefit from the effect of scale. The unit price of SWHs in terms of A_{SC} (flat plate solar collectors) is shown in Fig. 4. For all three scales of SWHs, the variation of unit price follows the similar trend. However, the unit price of a larger scale SWH (A_c = 5-10 m^2) is only about half in comparison of that a smaller scale SWH (below 3 m^2) from 2001 to 2007. The increase of unit price over the next two years slightly reduces the benefit of scale effect. In Taiwan, SR ranged from 18.3% to 21.3% from 2001 to 2007. Small variation was also observed for Kaohsiung city. In 2008, the big jump in the unit price of a SWH resulted in a much lower SR (～15%). With the revised incentive programs, SR was equal to 22.2% and 50.6% in Taiwan and Kaohsiung city, respectively. In the remote islands, SR in Penghu county was lower than that in Kiemen county, particularly in 2006 and 2007. It is not known why the unit price of a SWH was much higher in Penghu county at this moment. With the revised incentive program by BEMOEA, SR in Penghu county increased to 29% in 2009. In Kiemen county, total financial incentives (BEMOEA and regional government) accounted for about 51% and 89% of the total installed cost in 2008 and 2009, respectively. This can exactly explain the fast growth of SWH sales.

The efficiency of financial incentives can be valued in terms of their role in reducing the effective total installed cost to the user. However, Srinivasan [4] pointed out governments might choose to subsidize certain sections of consumers as a part of development strategy. The discounted prices could lead to supply-side distortions. Inappropriately designed subsidy programs could end up being counterproductive. As mentioned above, the SWHs deployed in Taiwan were almost in residential sector

and the average size of households in Taiwan and Kiemen county was also roughly the same. Thus other than the climatic conditions (sunshine hours and solar insolation), the system design in terms of A_{SC} should be roughly the same in order to meet the requirement of hot water production. From 2001 to 2008, there is slight variation in the average A_{SC} (= 4.05-4.37 m^2) for a SWH in Kaohsiung city followed by an 8% increase (A_{SC} = 4.64 m^2). In Kiemen county, there were only 65 systems deployed between 2001 and 2006. The average A_{SC} (= 3.92-4.95 m^2) might not be statistically meaningful. However taking into the average A_{SC} from 2007 (27 system) to 2009 (745 systems) into account, it increased from 3.43 to 5.95 m^2 (over 70% increase). This phenomenon is of interest. Possible explanation is given as below.

According to the average daily global solar insolation in Taiwan, the daily production of 50°C hot water by solar collectors is estimated to be 75 liters per square meter. On the other hand, the average consumption of 50°C hot water is about 60 liters per person (or 180 liters per household). Thus as a thumb of rule with the system design for a SWH, the ratio of persons of households and A_{SC} is approximately equal to one in most of common practice. Taking the average size of households in Kiemen county into account, it is highly speculated some SWHs deployed could be over designed. Note that the installation costs might be remained unchanging for a smaller or larger residential SWH. However, hardware costs could be mainly scaled with A_{SC}. When the unit price of solar collectors (NTD/M^2) is less than the total financial incentives by BEMOEA and Kiemen county government (9000 NTD/m^2), the subsidy could approach the total installed cost . As a consequence, an over design system might result in the mismatch between demand and production of hot water. The net energy saving is also distorted. Further, the tremendous enlargement of market size with such a high-level SR might result in a negative impact. It is highly possible some local installer/dealers might go out of business upon the termination of these subsidy programs. Then, the SWH users could suffer from a lack of post-installation service for the remaining portion of the system's technical lives thereafter [4].

CONCLUSIONS

The direct subsidy on the users' side has definitely been the driving force on the market expansion in Taiwan over the last two decades. However, the tremendous sales increase due to the cross subsidy programs appears to have a negative impact on the long-term development of local market in Kiemen county.

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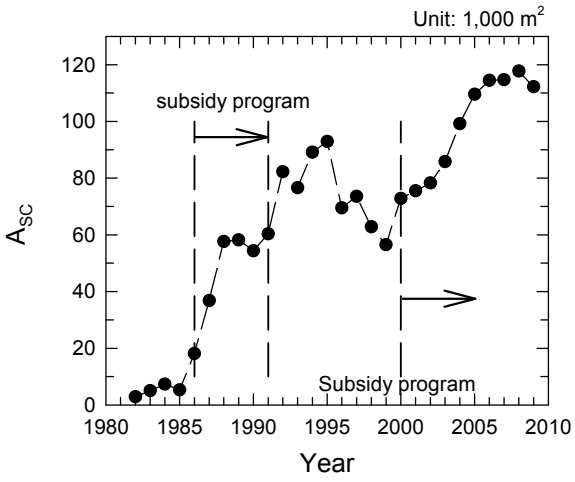

Fig. 1 Area of solar collector installed

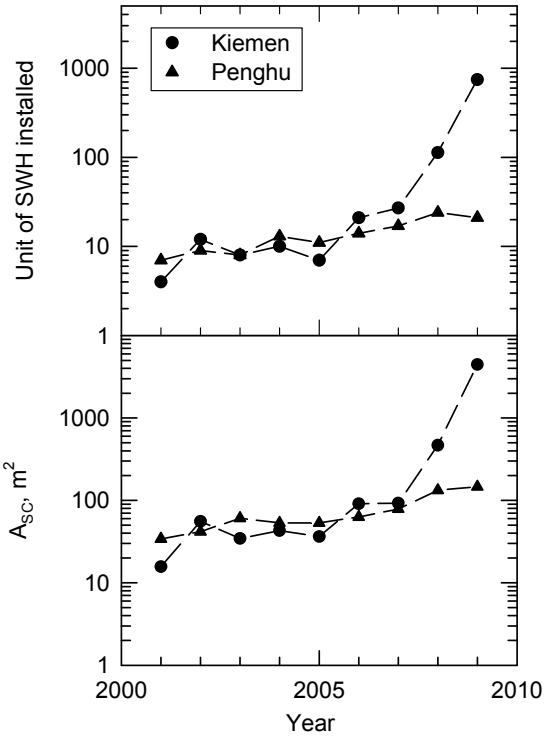

Fig. 2 SWHs in remote islands

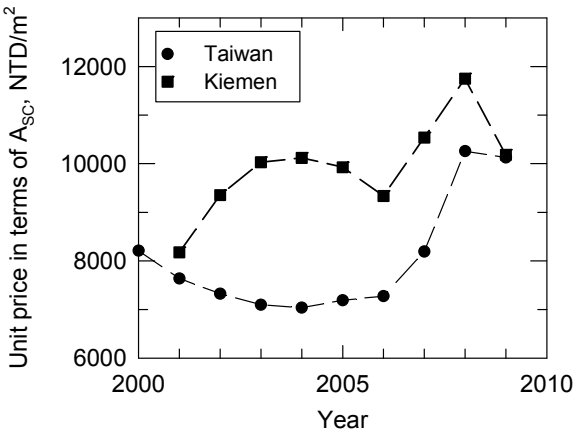

Fig. 3 Unit price of SWHs in terms of A_{SC}

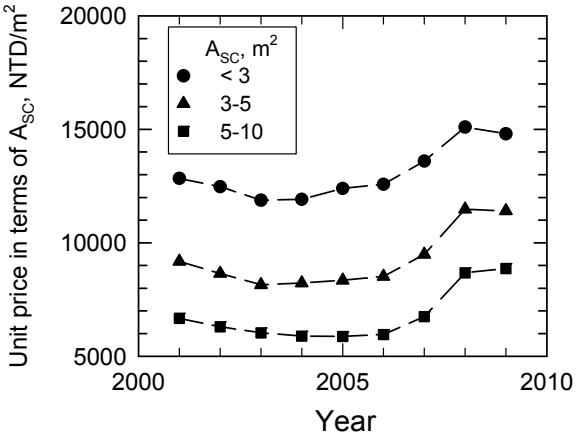

Fig. 4 Unit price in terms A_{SC}