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Exploitation of Solar Thermal Energy for Water Heating

Wongee Chun*

온수 급탕을 위한 태양열 에너지의 이용

천 원 기*

ABSTRACT

Use of solar thermal energy could play a vital role for those countries whose national resources are quite poor and no sustainable alternatives are readily available. This is why many scientists and engineers around the world have spent their time and efforts to capitalize in solar energy. Among various renewable technologies, solar water heating is a very simple concept with well-known principles and has been around more than a century. In Korea, however, decision-makers and engineers costly witnessed the discrepancy between technological applicability and economic availability during the last two decades. This study examines the past and present statistics of solar utilization and makes a very careful prediction of solar dissemination in the new millennium. Also investigated were new solar technologies that have emerged since late 1990s, which is yet to be tested in Korea.

Key Words : Solar energy, Water heating, new technologies

Ⅰ. INTRODUCTION

When compared with other major developed countries, Korea still has an extremely vulnerable energy supply structure depending well over 90% on foreign imports. This energy dependency has too be dealt with if Korea is to keep its pace of economic growth as it deed in the past decades. Demand for energy is expected to increase steadily worldwide as more countries become industrialized and people prefer to pay more for the energy they consume if they feel more comfortable that way: More people are driving these days and most of households have two or three electric chillers. They prefer to stay cooler in summer and warmer in winter. These trend in energy consumption would persist for some time unless a cataclysm takes place to reverse it.

With world societies approaching critical stage in their industrial development, the need for new energy technology becomes imperative. The threat of dwindling energy resources could force dramatic reductions in growth. Failure to meet these challenges for future generations will negatively effect future survivability, growth and development measured in

* 제주대학교 기계에너지생산공학부, 첨단기술연구소
Faculty of Mechanical, Energy & Production Eng., Research Institute of Advanced Technology, Cheju Nat'l Univ.

human suffering and societal decay. Use of solar thermal energy could play a vital role in this regard without undue difficulties. This is one of the important reasons why many scientists and engineers have spent their time and efforts to capitalize in solar energy.

In principle the rapid development of new energy related technologies including those of solar energy can offset the danger of shortage. However. there are many difficulties and hurdles to cope with from its incubation to its dissemination even for a very simple new technology. The difficulties of providing effective planning and coordinated development is that too many isolated forces come into play. Many technologies are developed for example from commercial ventures to produce wealth. An effective development motivator nor procedure for longer term needs are seldom found. Rather responses are more commonly derived from immediate fears or the desire for long term profits. With government development resources directed to short-term results and commercial recourse directed to short term profits. it is difficult to find an effective resource and development medium for society's longer term needs. The exploitation of solar thermal energy in Korea. unfortunately. underwent these experiences of mismanagement and entanglement from time to time. Solar water heating is a very simple concept with well-known technologies and there should have been only rosy-fingered future for its dissemination. In reality. however. practitioners and engineers costly witnessed the discrepancy between technological applicability and economic availability. which is yet to be narrowed. Some decision-makers. engineers and entrepeurs say that solar thermal heating of water created negative feedbacks and prejudices with regard to new energy development and its utilization. This is solely based on unfounded criticism and just an excuse to make up for any abortive efforts that might have been caused otherwise.

There should be a process of evaluating broader needs of society and the effects of technological innovation as a prerequisite to development. This is a very rational and prudential approach that one should follow in any execution of development program. Solar thermal energy program in Korea deems to take every step of this process. Many demonstration projects were conducted when new solar technologies were to be utilized more broadly. By doing this. it is possible to positively and more efficiently influence the development and effectiveness of an innovative development. By careful preparation many adverse commercial and societal side effects can be minimized if not avoided. In contrast the effort to apply after-the-fact corrective measures to solve the bad side effects tend to be only partially effective and are often disruptive. This kind of problem can be avoided for example the potential adverse impacts are directively integrated with the development engineering process itself. Guided by these and other constraints in the earliest stages of engineering development can help accurately integrate the need and the technical problems in relationship to the solutions developed. This can be accomplished without denying the potential for profit and will provide an efficient path for development under conditions of limited sources. Development of new technologies for solar water heating did not always followed this track but managed to remain in this track. Although there was a plunge of solar demand due to economic crisis in late 1990s causing sluggishness in its utilization. it is coming back slowly but more vigorously.

Integrating broader constraints beyond direct technical performance have produced better solutions more efficiently. The process is still in the perfecting stage but has already yielded several new innovative energy related technologies. Of particular value in the commercial development of new solar products in market is the use of the "cost constraint" prerequisite in the solar collector. the major element of any solar products. With the advent of New Millennium. new solar technologies are emerging replacing the conventional technologies based on flat plate type solar collectors.

II. STATISTICS IN PERSPECTIVE

The sun provides us an inexhaustible potential for energy which today can be usefully exploited by means of high technology.

Currently. there are many solar collectors that differ in design. operational characteristics. component materials. functional requirements. and etc.. Some are made more sophisticated than others and function better with wider range of application.

Of course. different technologies could be applied to manufacture the same type of solar collectors depending on their availability. However. in Korea. most of the solar water heating systems marketed are based on flat plate type solar collectors.

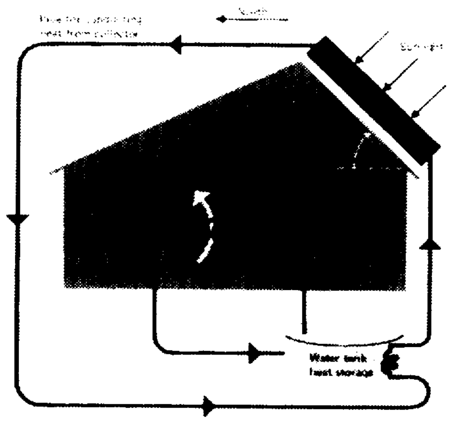

Fig. 1. Solar energy collection and storage.

1) Solar Energy(Thermal) Project

Table 1. R&D projects (in million won)

Classification	~'94	'95	'96	'97	'98	'99	Total
No. of Projects	28(68)	4(6)	3(7)	2(8)	3(8)	2(7)	42(104)
Government	2.315	365	892	1.658	1.273	797	7.300
Private	1.119	10	219	240	268	42	1.898
Total	3.434	375	1.111	1.898	1.541	839	9.198

* Number in parenthesis indicates total number of projects in that year

2) Accomplishments

Table 2. Present status of research & development

Classification	Contents
Solar Water Heaters for Low Temperature Application	· Commercialization of flat plate collectors · Commercialization of small water heaters for residences (Natural circulation type. Phase changing type) · Utilization of active type solar water heaters · Development of temperature difference control systems
Medium & High Temperature Solar Collector System (Application)	· Development of medium & high temperature collectors (PTC type. DISH type) · Solar cooling system · Solar heat storage system(Storage materials for low and medium · high temperature applications) · Solar thermal power generation (Basic study)

3) Solar Water Heaters

Table 3. Solar water heaters deployed (in units)

구 분	~'90	'91	'92	'93	'94	'95	'96	'97	'98	계
Domestic	11.453	2.142	2.036	4.026	7.796	16.106	41.149	77.226	12.012	173.946
Golf Club Houses	34	14	10	8	3	6	6	11	11	103
Fish Farms	5	8	3	-	3	5	5	5	10	44
Soil Heating	-	-	-	-	-	-	9	71	40	120
*Others	2.450	3	5	4	6	1	9	28	49	2.555
합 계	13.942	2.167	2.054	4.038	7.808	16.118	41.178	77.341	12.122	176.768

* Others include solar water heaters for public bath facilities. motels and restaurants

4) Market Growth

◇ Plunge of market following the 1998 economic crisis
◇ Steady increase in the use of medium size heaters since 1996

Table 4. Market growth (in 100 million won)

Classification	'91	'92	'93	'94	'95	'96	'97	'98
Size of market	124	95	149	292	592	1.475	2.770	511
Growth rate		-23%	57%	96%	103%	149%	88%	-82%

5) Problems

- High dependency on nighttime electricity
- Low incentives for the use of solar products
- Insufficient A/S and malfunction of minor parts
- Negative feedbacks due to bad applications
- Use of low quality parts and poor design
- Minor problems affecting system efficiency

6) Competitiveness

▷ Conditions

- 100% investment by a household without any subsidies
- life span of system : 10yrs
  - increase in fuel price : 5%/year
- maintenance fee : 5% of system cost/yr
- discount rate : 8%/yr (regular savings interest rate-bank)

▷ Comparative analysis (with diesel)

- swimming pool heating : 450won/liter
- public bath heating : 620won/liter
- restaurant water heating : 640won/liter
- space and water heating of motels : 600won/liter
- space and water heating of residences : 770won/liter

▷ If 296.000 units are deployed nationwide. 125.000 toe of energy could be saved per year. This amounts to saving of 145.000㎘ of oil per year.

▷ In general. solar systems become more economical when they are used more frequently throughout the year requiring low temperature water heating. Especially. the systems are even competitive against the present oil price if used for large amount of water heating in swimming pools. public baths and motels.

III. SOLAR WATER HEATERS WITH SOLAR VACUUM TUBE COLLECTORS

Solar vacuum collector tubes are quite different from the well-known flat plate types of solar collectors. In order to prevent the heat loss that usually occurs in solar collectors due to the circulation of air, the absorber is made by harnessing the vacuum technology. There are currently two different types of solar vacuum collector tubes. One utilizes a single evacuated glass tube with a heat transfer device(such as a heat pipe) inserted.

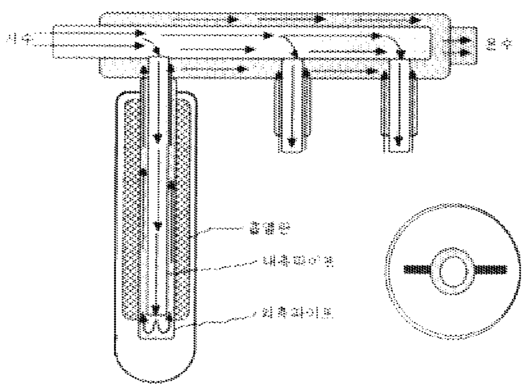

Fig. 2. Metal annular pipe inserted.

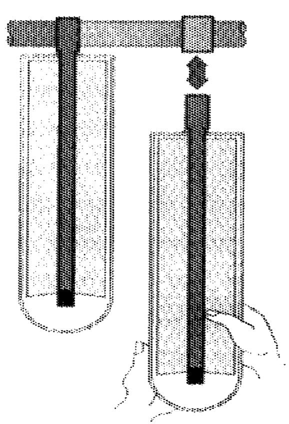

Fig. 3. Heat pipe inserted.

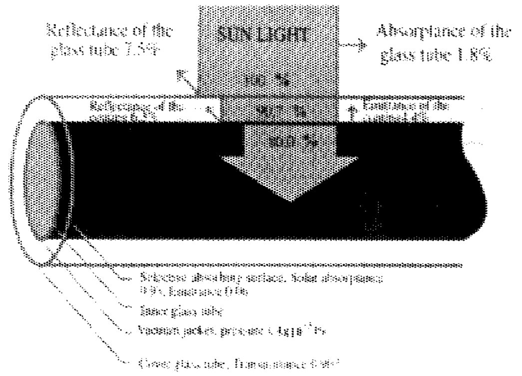

Fig. 4. Structure of all-glass evacuated tube.

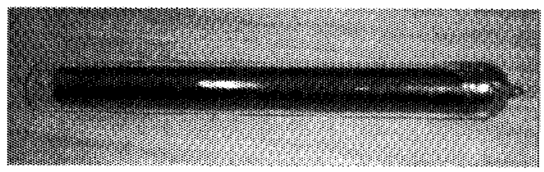

Fig. 5. An all-glass evacuated tube.

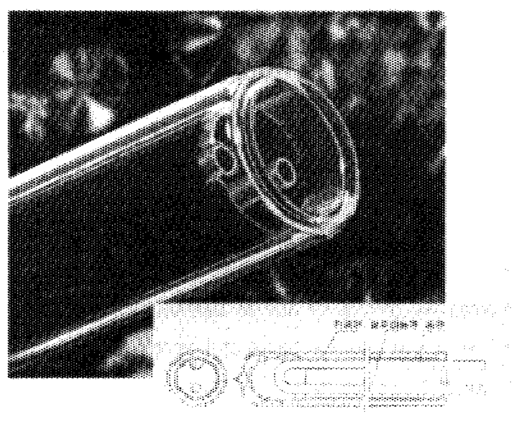

Fig. 6. Metal "U" tube inserted inside an all-glass evacuated tube.

The other is so-called "all-glass evacuated solar collector tube. This is made by using two glass tubes of different size where the smaller one is inserted into the larger one before their openings are soldered together. Evacuation process immediately follows such that the small gap between two glass tubes are evacuated.

Ⅳ. LARGE SCALE WATER HEATING FOR SEASONAL STORAGE

A CSHPSS(Central Solar Heating Plant with Seasonal Storage) of its first kind was built on Cheju Island by the Korea Institute of Energy Research(KIER) in 1998. Among many potential sites. Cheju was finally chosen by KIER staffs for its installation as preliminary studies (done by KIER) indicated that Cheju would produce better results that other locations in Korea due to its mild weather in winter and resonable solar irradiation during summer. Moreover. Cheju is famous for tourism and it could draw public attention more effectively that any other places in Korea.

The basic idea of seasonal storage of solar energy is to fix the seasonal discrepancy between solar energy Supply and heating load. The solar irradiation is generally high during summer and low in winter. There is about 6 months phase shift between energy supply and demand. The best cure for this discrepancy is the utilization of thermal storage. Since the storage period is relatively long compared with the conventional small-sized daily storage systems. a large volume of thermal storage is generally recommended. The large volume of storage is meaningful only when a large area of collector is accompanied. This is the reason why large systems generally used in CSHPSS.

The Cheju DSHPSS system consists of two arrays of collectors(182㎡). a medium-sized storage tank (600㎥). a heat exchanger and consists of evacuated-tube type solar collectors imported from Germany and the other array is an array is an array of flat plate type collectors domestically fabricated. The system was designed to provide heating for an office building and a greenhouse for agriculture research.

Ⅴ. CONCLUSION

Since early 1980s. the national solar energy program grew rapidly to include not only basic and applied R&D. but also participation with the private sector in demonstration projects. commercialization. and information dissemination. In addition. the government introduced market incentives. such as business and tax credits. low interest low and other subsidies. The government is still responsible for playing a central role in supporting the deployment solar water heaters. it is expected that new types of solar collectors will replace the traditional flat plat type solar collectors in harnessing solar collectors in harnessing solar thermal energy in coming years drastically improving the system efficiency.

REFERENCES

1) John A. Duffie and William A. Beckman. 1980. "Solar Engneering of Thermal Processes". pp.250 ~ 270.

2) Ghoneim A. A.. Fisch N.. Ammar A. S. A. and Hahne E.. 1994. "Investigation of Evacuated Tube Collectors". *Solar Energy*. Vol.16. pp.16 ~ 23.