RESEARCH AND DEVELOPMENT OF SOLAR THERMAL ENERGY IN THAILAND

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ABSTRACT

The annual average intensity of daily total solar radiation in Thailand is about $17 \text{ MJ/m}^2 \text{ day}$ which can be considered as fairly good. Several types of solar thermal equipment and systems have been developed in Thailand. Though solar water heaters have already been manufactured in the country, research and development to increase the efficiency and to reduce the first cost are still continued. Industrial standards for solar collectors and water heaters should be set up. Research and development on horizontal-surface and vertical-surface solar stills have been advanced enough for demonstration of large solar stills. Free-convection solar dryers have been developed and used commercially with some success. Large-scale forced convection solar dryers are being developed for bulk agricultural products and industrial applications. Other solar thermal equipment under research and development are absorption refrigerators, water pumps, solar ponds for heat and power generation. Since solar radiation in Thailand consists of 50% diffuse component, solar concentrators which can collect only direct radiation would be less economical than flat plate collectors which can collect both diffuse and direct radiation.

SOLAR RADIATION

Daily total solar radiation on horizontal plane in Thailand has an annual average intensity of about $17 \text{ MJ/m}^2 \text{ day}$ or $4.72 \text{ kWh/m}^2 \text{ day}^1$ which is approximately equal to heat released from combustion of 1 kg of dry wood. Diffuse component of the solar radiation is quite high and on the average about 50% of the total solar radiation.

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Over fifty pyranometers for measuring total solar radiation exist in Thailand. Most of them have however not been regularly calibrated since there is no active calibration centre for solar radiometers in this region. Only a few pyrliometers have been kept in working order.

Several models for predicting solar radiation in Thailand have been developed. One model is based upon the past data on sunshine durations covering a period of about 5 years.² Another model was developed from 10-year records of total solar radiation in Thailand³. A total radiation model based upon satellite images taken through infrared channel has been recently developed.⁴

Fig.1 Solar Assisted Tobacco Curing Barn

WATER HEATING

More than five companies in Thailand manufacture flat plate collectors for water heating. Total areas of installed collectors exceed 40,000 m². Current annual production of flat plate collectors in the country is about 10,000 m². About fifty percent of the collectors are installed in hotels and hospitals and the rest are used for domestic water heating. An economic assessment indicates that a pay-back period of about 7-10 years may be achieved in comparison with electric water heating.²

During the last five years, several types of improved flat plate collectors have been developed in Thailand such as serpentine double₇-glazed collectors⁵, compound parabolic collectors⁶, reversed flat plate collectors. Details of these

improved collectors are available for manufacturing if required by the market or for integration into other solar thermal equipment such as absorption refrigerators, thermal water pumps, etc.

Fig.2 Solar Thermal Collector having two absorbing surfaces⁸

To promote the quality of locally produced flat plate collectors, an industrial standard for solar thermal flat plate collectors is being drafted by Thai Industrial Standards Institute⁸ and is expected to be completed within 1988. A relatively simple test standard for thermo-syphon solar water heaters has been developed⁹ and unofficially used in Thailand. A national test standard for solar water heaters should be urgently set up. A solar simulator has been designed and built in order to facilitate testings of solar thermal and photovoltaic equipment¹⁰

To improve the efficiency of flat plate collectors, techniques for selective coating of black-chrome and black-nikel have been developed in Thailand upto pilot-plant scale¹¹, and are readily available to be transferred to industry. A study on different types of bondages between fins and tubes of flat plate collectors was conducted and suitable types of bondages were identified¹².

DISTILLATION

It has been estimated that the solar energy used in salt production from sea water in Thailand is equivalent to about 19 million barrels of oil per annum¹³. Several types of solar stills with horizontal absorbing surfaces have been developed¹³. Portable ones have their basins made of aluminum or stainless steel. Basins of

stationary stills are normally made of bricks or concrete. Performance tests of portable and largest solar stills have been conducted in the field. The larger demonstration still has the total absorbing area of 200 m² and is used to supply distilled water to a large laboratory.¹⁴

Fig.3 A 200 sq.m solar still¹⁴

A large solar still with horizontal absorbing surface requires a large installation area which can be expensive in a city. The problem can be lessened if a vertical surface solar still is installed on a parapet or a wall of a building. Development of vertical surface stills began about six years ago¹⁵. Optimum designs have already been developed for various types of installation¹⁶. Performance test and demonstration of a large vertical surface solar still is now being planned.

DRYING

Solar dryers have been developed for drying of grains, fruits, vegetables, meat and fish¹⁷. Solar energy used in paddy drying alone is estimated at about half a million barrels of oil equivalent per annum. Free-convection solar dryers are suitable for domestic or small-scale commercial drying. Field tests of box-type and cabinet-type free-convection dryers indicate that they are suitable for drying of bananas, meat and fish¹⁸. Commercial drying of bananas and other fruits in free-convection dryers has already achieved some success in the northern part of Thailand.¹⁹

Fig.4 Free-Convection Solar Dryer¹⁹

Drying of bulk materials such as grains generally requires forced convection. A pilot-scale solar drying hut has been developed to dry and also store up to seven tons of paddy.²⁰ A solar assisted tobacco curing barn has also been developed to save fire-wood²¹ which is a major cause of deforestation in Thailand. Development of a large-scale maize dryer has been in progress for about two years²² As research and development on large-scale solar dryers are very active, it is expected that industrial applications of solar drying may soon be achieved in Thailand.

COOKING

Several types of solar cookers have been developed such as flat-plate-collector-type using heat transfer oil as the working fluid, parabolic dishes with sun-tracking mechanism, etc. Like most countries, social acceptance of solar cookers encounters several barriers. Firstly, users of solar cookers are exposed to solar radiation. Secondly, solar radiation is not sufficient for cooking breakfast and evening meal. A thermal storage has been developed for evening cooking²³ but found to be too expensive for a practical use.

Since fire-wood, charcoal and LPG are still available in Thailand at relatively cheap prices, it will be very difficult to popularize solar cookers in the country.

THERMAL POWER SYSTEMS

A physical model of a central tower system with tracking heliostats was designed and constructed²⁴. Simulation of the physical model shows that the system should be technically workable for Thailand but its initial cost would be too high for an economical operation.

A distributed collector system was also developed²⁵. The system consisted of three tracking parabolic troughs connected in series with the total collector area of 12 m². The system demonstrated a local technical capability but its first cost was also too high for practical purpose.

The above two types of solar thermal power systems accept only direct solar radiation, hence for operation in Thailand, the diffuse solar radiation amounting to 50% of the total radiation would be wasted. Development of solar ponds for heat or power generation would be more promisingly economical than the concentrator systems since solar ponds accept both diffuse and direct radiation.

A study was conducted on a circular solar pond with an area of about 50 m² and brine was used as the working fluid²⁶. Another study on a rectangular pond of 50 m² and also with brine as the working fluid was used as a basis for technical and economic assessment under operating conditions in Thailand²⁷.

OTHER THERMAL SYSTEMS

Development of absorption refrigeration systems using solar heat for the generation of ammonia from ammonia–water solution has progressed to construction and performance tests of prototypes^{28,29}. Though fabrication technique exists in the country, the first cost of the systems is still much too high for practical applications. Research on another type of absorption system using methanol and activated charcoal has received more attention recently³⁰ since both alcohol and activated charcoal are locally produced.

A solar thermal pumping system using normal pentane as the working fluid was designed, constructed and tested. Though the system was workable, its efficiency was still below 1%³¹ which was much lower than a photovoltaic pumping system.

RECOMMENDATIONS

1. A regional centre for calibrating solar radiometers should be seriously considered by ASEAN.
2. Research and development to increase the efficiencies and to reduce the costs of solar liquid heating systems should be supported. National standards for

performance tests and fabrication of hot water heating systems should be urgently set up.

3. Performance tests and demonstration of large solar stills should now be conducted in industry and large laboratories. Research and development of solar distillation of ethanol fermented from agricultural products should be supported.
4. Small free-convection solar dryers for fruits, meat and fish should be immediately promoted in rural households. Development of large solar dryers for bulk agricultural products and industrial processes should be accelerated.
5. Research and development on solar thermal refrigerators, water pump and solar ponds should be continued.
6. To avoid repetitive works, solar energy researchers are recommended to obtain detailed R&D information from the following centres:
 - (a) Renewable Energy Research Information Centre, AIT, P.O. Box 2754, Bangkok.
 - (b) Central Library, KMITT, Bangmod, Bangkok 10140.

REFERENCES

1. Exell, R.H.B. and Saricali, K. The Availability of Solar Energy in Thailand. *Research Report No. 63*, AIT, Bangkok, 1976.
2. Tongprasert, M. *Use of Hot Water in Residence and Industry*. Technological Promotion Association (Thai-Japan), Bangkok, 1985.
3. Kirtikara, K. and Tia, V. Development of Solar Radiation Model and Map of Thailand. *Proc. of Simulation and Design in Solar Energy Applications*, UNESCO-KMITT-USAID, Bangkok, May 1984.
4. Sorapipatana, C. Mapping of Solar Radiation over Southeast Asia by Meteorological Satellite Images. *DEng Thesis*, Energy Technology Division, AIT, Bangkok, 1988.
5. Wibulswas, P. and Teetakaew, P. Comparative Performances of Double-Glazed Flat Plate Collectors. *Proc. of 4th SOLERAS Workshop on Solar Thermal Collectors*, Midwest Research Institute, Kansas City, 1983, pp. 207-215.
6. Jitnomrat, N. et al. Performance of CPC Concentrators. *Research and Development Bulletin*, Dec. 1982, 5, (2), 34-49.
7. Wibulswas, P. and Nigam, D. Further Improvement of a Reversed Flat Plate Collector. *Proc. of 6th SOLERAS Workshop on Solar Energy Applications*, MRI, Kansas City, 1985, pp. 577-587.
8. Draft Standard on Flat Plate Collectors. Thai Industrial Standards Institute Bangkok, 1987.

9. Wibulswas, P. Performance Testing and Correlation of Solar Domestic Hot Water Heaters. *Proc. of 4th Asian School on Solar Energy Harnessing*, AIT, 1985, pp. 153-162.
10. Kirtikara, K. Solar Research at a Thai Institute. *RERIC News*, 1985, 8, (4), 7.
11. Kirtikara, K. et al. Black-Chrome Selective Surface Study on Facilities for Pilot Scale Production. *Proc. 4th Asian School on Solar Energy Harnessing*, AIT, 1985, pp. 86-110.
12. Soponronnarit, S. and Noparatkrailas, V. The Optimum Spacing of Strapping Wires in a Solar Thermal Flat Plate Collector. *Renewable Energy Review J.*, 9, (10), 29-38.
13. Wibulswas, P. Review of Research and Development on Solar Distillation in Thailand. *Renewable Energy Review J.*, 1984, 6, (2), 101-111.
14. Department of Science Services, Ministry of Science, Technology and Energy, Bangkok.
15. Wibulswas, P. et al. Development of Solar Stills Having Acrylic-Plastic Covers in Thailand. *Solar Heating, Cooling, Desalination, Alternative Energy Sources IV*. Ann Arbor Science, Michigan, 1982, pp. 385-394.
16. Kiatsiriroat, T. et al. Transient Simulation of Vertical Solar Stills. *Energy Conversion and Management*, Pergamon, 1987, 27, (2), 247-252.
17. Wibulswas, P. Recent Development of Solar Drying in Thailand. *Regional Meeting on Solar Drying*, FAO Regional Office, Bangkok, Jan. 1986.
18. Putranon, R. Natural Convection Cabinet Drying. *Research Report, Renewable Nonconventional Energy Project*, USAID-NEA, Bangkok, 1984.
19. Rakvichien, W. and Wibulswas, P. Solar Drying of Bananas. *RERIC News*, 1987, 10, (1), 1-3.
20. Soponronnarit, S. et al. A Drying-Storage Solar Hut. *Renewable Energy Review J.*, 1986, 8, (1), 49-54.
21. Boon-Long, P. Solar-Assisted Curing of Tobacco Leaves. *Research Report, Renewable Nonconventional Energy Project*, USAID-NEA, Bangkok, 1984.
22. Tongprasert, M. et al. *Solar-Biomass Grain Dryer Progress Report*, National Research Council of Thailand, 1987.
23. Hemayakorn, L. and Wibulswas, P. Thermal Storage for Solar Cookers. *Workshop and Exhibition on Solar Cookers, Centre of Energy Study*, IIT, New Delhi, May 1983.

24. Tongprasert, M. et al. A Solar Power Plant; Study and Design. *A Research Report*, Faculty of Engineering, Chulalongkorn University & EGAT, Bangkok, 1983.
25. Wibulswas, P. et al. *Solar Thermal Electric Power System: Tracking Parabolic Trough System*. School of Energy & Materials, KMITT & EGAT, Dec. 1984.
26. Chantranuluck, S. and S. Simulated Performance of a Solar Pond in Thailand. *Proc. of Nonconventional Energy and Applications*, KMITT-TPA (Thai-Japan), Bangkok, 1985.
27. Takabutr, K. Economic Study of Solar Pond Power Plants in Thailand. *Renewable Energy Review J.*, Jun. 1987, **9**, (1).
28. Bhumiratana, S. Solar Refrigeration, Solar Thermal Processes in Thailand. *Renewable Nonconventional Energy Project*, USAID-NEA Thailand, 1984.
29. Exell, R.H.B. et al. Village-Size Ice Maker. *Proc. of Heat, Mass and Momentum Transfer*, Engineering Institute of Thailand and Prince of Songkla University, Haadyai, Apr. 1983.
30. Exell, R.H.B. et al. Charcoal-Methanol Absorption Refrigeration. *ISES World Congress*, Hamburg, Sept. 1987.
31. Tongsathitya, A. and Ratanaprakarn, O. Development of a Simple Solar Pump. *Proc. of Heat, Mass and Momentum Transfer*, EIT & PSU, Haadyai, Apr. 1983.