SPECIAL ARTICLE

J. Sci. Soc. Thailand, **5** (1979) 110-116

RESEARCH AND DEVELOPMENT ON SOLAR ENERGY IN THAILAND

P. WIBULSWAS and K. KIRTIKARA

King Mongkut Institute of Technology, Thonburi, Bangmod, Bangkok 14, Thailand

(Received 12 July 1979)

Introduction

At present, Thailand obtains more than 80% of her energy requirement from imported patroleum and its products[1] which constitute over a quarter of the national spending on imported goods. As the energy consumption of Thailand increases at a rate of about 10% annually and as the price of petroleum continues to rise rapidly, the deficit in trade balance will soon be so large that the economic development of the country will be hindered unless indigenous sources of energy are sufficiently developed.

Since the daily average solar radiation in Thailand[2] is about 17 MJ/m^2d which is quite good, solar energy has high potential to be developed as an alternative source of energy for the country. A number of educational institutes and government agencies are now engaged in solar energy research and development. However, some problems still exist, such as shortages of experienced technical personnel and research fund and lack of solar energy master plan.

Current Research and Development Activities

From recently published papers, current activities on solar energy research and development in Thailand may be summarized as follows:

Water heating

Solar water heaters using flat plate collectors and auxiliary heaters are now produced in Thailand by a few local manufacturers whose sales altogether were over US$ 100,000 in the last six months. Solar water heaters are used mainly in hotels, hospitals and clinics. Domestic use of solar water heaters also shows an increasing trend[3,4].

TABLE I: SOLAR ENERGY R & D IN THAILAND

R & D Activities	R & D Institutions
Water heating	King Mongkut Institute of Technology Thonburi; National Energy Administration; Solar Industrial Co. Ltd.; Soltech Co. Ltd.
Drying	Asian Institute of Technology; Chulalongkorn University; King Mongkut Institute of Technology Thonburi and North Bangkok; Prince of Songkla University.
Distillation	Asian Institute of Technology; King Mongkut Institute of Technology Thonburi; Department of Science.
Cooking	King Mongkut Institute of Technology Thonburi; National Energy Administration.
Refrigeration & air conditioning	Asian Institute of Technology; Chulalongkorn University; King Mongkut Institute of Technology Thonburi; National Energy Administration.
Pumping	Asian Institute of Technology; National Energy Admininistration.
Thermal Power	King Mongkut Institute of Technology Thonburi; Chulalongkorn University; Electricity generating Authorities of Thailand.
Photovoltaics	Chulalongkorn University; King Mongkut Institute of Technology Thonburi and Ladkrabang.
Wind power	Chulalongkorn University; King Mongkut Institute of Technology Thonburi; National Energy Administration; Prince of Songkla University; Usa Industrial Co., Ltd.
Bio-energy conversion	Department of Public Health, Thailand; Institute of Science and Technology, Chulalongkorn University; King Mongkut Institute of Technology Thonburi; Department of Agricultural Technology.

The current production cost of a complete water heating system[5] including a storage tank is under US$ 200 per m^2 of collector area. At present, research and development works are being carried out to lower the production cost and to increase the efficiency of the water heater[3].

Different collectors with operating temperatures near the boiling point of water or above, such as evacuated tube collecters[6], reversed flat plate collector, focusing collectors, etc. are also being developed for industrial applications[3].

Though solar water heaters are installed mainly in urban areas, they have potential to be used in rural areas for a number of applications such as in health posts, food processing and preservation.

Distillation

Solar stills have been known to produce high-quality distilled water. A portable solar still is generally made of aluminium or stainless sheet and has a black butyl rubber sheet as its absorbing surface. This type of still operating in Thailand may yield over four litres of distilled water per m^2d at a cost under US$ 0.01 per litre[3,7].

A low cost stationary solar still has recently been developed in Thailand[8]. The still is made of brick and mortar. Its absorbing surface consists of mortar mixed with black ferro-ferric oxide powder which is much cheaper than the black butyl rubber sheet. Without taking the cost of land into account, the stationary still may yield distilled water at a cost of less than US$ 0.005 per litre.

The portable solar still is suitable for urban uses such as for drinking water, industrial applications, etc., because of its high yield per unit area and high cost of land. The stationary still is however more suitable for rural areas where clean drinking water is scarce; since it can be easily constructed by a brick-layer using locally available materials.

It has been suggested that work might be done to develop more efficient solar stills that return the latent heat of condensation of distillate to the incoming raw water instead of losing it to the environment[9].

Drying

The conventional method of drying agricultural products by spreading them out on the ground in the sun suffers from serious disadvantages. The material is exposed to dirt and to contamination by insects, and in the wet season, the produce is often spoiled by the rain. Free convection box dryers and cabinet dryers with separate collectors have been developed and are being tested in the field[3] for drying fruits, cash crops and marine products. The prototypes of grain dryers using free and forced convection are also being tested[10,11]. It may be stated with confidence that some types of solar dryers are now ready to be popularised in rural areas. However, further development works are still needed for drying tobacco, lumber, etc., where precise controls of temperature and humidity are required[4]. As an agricultural country, research and development on solar drying should be regarded as a priority.

Cooking

Solar cookers using flat plate collectors or parabolic dishes have been developed at a cost of about US$ 30-50 per m^2 of collector areas. Up to now, the solar cookers have not yet been widely accepted by the public owing to social problems such as housewives' objection to cooking in the sun, no solar energy to cook evening meal, availability of firewood, etc.[4]. Inspite of these shortcomings, solar cookers are still attractive in term of fuel cost and saving of trees which would otherwise be cut down to make firewood and charcoal. Development is being conducted to bring solar heat into the kitchen and to provide thermal storage for warming up evening meal[3].

Refrigeration and air conditioning

As an agricultural country, solar refrigeration has high potential for food preservation. It is however rather difficult to develop a reliable and economical refrigerator. Solar heated absorption refrigerators using ammonia-water mixture are being developed for intermitten use in rural areas[12,13]. An absorption type refrigeration was recently modified to operate continuously by solar heat obtained from a parabolic trough[3]. The system is still too expensive and bulky. More research and development have to be done.

A large amount of electricity is now used for running air conditioning units in Bangkok. Solar heated air conditioning systems will save electricity for more beneficial uses such as industry, if the initial cost of the system is low enough. An imported solar heated absorption air-conditioning system using lithium bromide and water is being installed for a long term test at a building of the National Energy Administration[4]. It is hoped that if locally-made flat plate collectors are incorporated to the imported absorption refrigeration unit, the cost of solar air conditioning will be much reduced.

It may be finally added that mechanical vapour compression refrigeration may also be acheived by using a solar heat engine to drive the compressor, if the cost of the engine is sufficiently low.

Mechanical power

In principle, mechanical power may be generated from solar energy by means of thermal power cycles such as Rankine, Stirling, Brayton, etc. The costs of these solar engines, if produced, are still to high to compete with internal combustion engines.

Research work[3] is being carried out on a small Stirling hot air engine heated by solar energy via a combination of heliostats and a parabolic dish. The engine is expected to operate at a temperature of about 500° C with an output of about 100 W.

Water pumping

Lifting of water from deep wells, rivers and their tributaries are required for domestic and agricultural purposes in many rural areas, especially in the northeast of the country. Solar energy may be used for water pumping generally by means of solar heat engines, wind turbines, photovoltaics. Solar pumps are now commercially available, but they are far too expensive and inefficient.

A Rankine heat engine using focusing collectors with a concentration ratio of about 4 has been suggested[9] for water pumping. Another type of solar heat engine producing a vapour of insoluble fluid such as pentane to drive a piston pump is being developed in the country[14].

Water pumping by wind turbines have been known for centuries. Multiple-blade wind turbines for pumping water are now manufactured in the country by a local firm whose sale was over 100 units last year. Vertical axis turbines such as Savonious are being developed for more efficient pumping.

It should be noted that, with rapid advances in solid state technology, water pumps powered by solar cells may have better cost effectiveness than other types of solar pumps in the near future.

Generation of electricity

At present, over 5 million families in about 47,000 villages in rural areas of Thailand still have no electricity[4]. Solar-generated electricity seems feasible in the near future for remote areas where connection to national electricity grid will be too costly. Three methods of generation of electricity by solar energy have been considered in the country, namely direct conversion by photovoltaic cells, indirect conversions by solar thermal electric power systems and by wind turbines.

Silicon solar cells, initially developed for space programmes, now generate electricity at a cost of about US$ 50 per peak watt. With concentrated efforts on research and development, the cell electricity price may be reduced by a factor of 100 within 20 years. Thin film technology and development of solar cells for high solar radiation flux are the two promising areas[3].

Research and development works on solar cells fabrication processes such as diffusion and metal film evaporation under high vacuum have been carried out at Chulalongkorn University and King Mongkut Institute of Technology[3,15]. Applications of solar cells in the country are also being considered[16]. With sufficient financial support, it should be possible to develop indigenous technology necessary for producing solar cells locally within ten years.

Electricity Generating Authority of Thailand (EGAT) is studying the feasibility of a 1000 kWth solar thermal electric power system for Thailand. Two feasibility study projects on a central tower system and a distributed collectors system are being investigated by Chulalongkorn University and King Mongkut Institute of Technology Thonburi with financial supports from EGAT[16]. In the preliminary studies, a model of the DCS consisting of heliostats, parabolic troughs and tracking system is being developed to give a thermal output of 10 kW while a model of the CTS consisting of a heliostat, a central receiver, and a storage tank is being designed to give an output of 1 kWth.

It has been recently predicted that the CTS may be feasible for an electrical output above 1 MW and the DCS is likely to be more suitable for a rural area where an electrical supply less than 1 MW is required.

Generation of electricity by wind may be possible along the coastal areas and in the Gulf of Thailand. A small Savonious wind turbine coupled to a d.c. generator was locally built and tested a few years ago[3]. The unit generated about 50 We at the average wind speed in Bangkok.

Two wind electric power systems using a horizontal axis and vertical-axis wind turbines are being developed by Prince of Songkla University and King Mongkut Institute of Technology to generate about 1 kWe for rural areas[17] with financial assistances provided by EGAT[16].

Bio-energy conversion

Bio-gas plants have been introduced to the public in Thailand since 1960 by the Department of Health as a means to eliminate health problems arising from manure of domestic animals. Bio-gas and fertilizer are obtained as by-products.

In the fiscal year 1979, the Department of Health expects to install over 100 bio-gas plants in various parts of the country[18].

If the bio-gas is to be used as an alternative source of energy a number of problems have to be solved such as insufficient manure to feed digesters, high cost of construction, leakage of the gas holder, etc. Research and development works are being done on the use of vegetation as a substitute for manure. A continuously operating plant is also being investigated. A recent review[19] critically examined these problems.

With readily available molasses and cassava in Thailand, interest in the production of ethanol as a fuel has been recently aroused. Gasoline engines using a mixture of ethanol and petrol have been tested in laboratory and on the road with satisfactory results. However, a thorough feasibility study has to be made before an ethanol plant is set up.

Education and Promotion

Ministry of Education has a plan to introduce the knowledge of solar energy at the secondary school level. A course on solar energy is offerred as an elective at undergraduate level at Chulalongkorn University. King Mongkut Institute of Technology Thonburi has run a two year master degree programme in energy technology in which solar energy is the main theme, since 1977.

National Energy Administration has set up a unit to test and demonstrate various solar devices. It has also proposed a detailed work programme entitled "Study and Development of Renewable Sources of Energy" since 1977.

Electricity Generating Authority of Thailand has set up a solar energy group to study the utilization of solar energy for the generation of electricity and a conservation group to study the use of solar energy to reduce the amount of oil consumption.

Conclusions

Though Thailand has been engaged in various topics of solar energy research and development and some some solar devices are now ready to be used by the public, more supports from the government in terms of experienced technical personnel, research equipment and technical information are still needed for a successful development of solar energy as an alternative source of energy for the country. International cooperation such as exchanges of research workers and technical information will help accelerate the solar energy development which will be benefitial to all countries concerned.

References

1. Premmani, P. (1979) Situation, Problem Encounter and Scenarios in fulfilling Energy Demand in Thailand. *Workshop on Energy and Rural Development*, National Research Council of Thailand & East-West Centre, Pattaya, March, 1979.

2. Exell, R.H.B. (1975) Further solar radiation tables for Thailand, *J. Sci. Soc. Thailand* **1**, 240-244.
3. Wibulswas, P. and Kirtikara, K. (1979) Solar Energy and Rural Developmant. *Workshop on Energy and Rural Development*, National Research Council of Thailand & East-West Center, Pattaya, March 1979.
4. Chantavorapap, S. (1979) Development of Solar Energy in Thailand, *Workshop on Energy and Rural Development*, National Research Council of Thailand & East-West Center, Pattaya, March 1979.
5. Wibulswas, P. (1978) Economic Analyses of Solar Water Heater and Solar Stills in Thailand. *International Symposium-Workshop on Solar Energy, National Research Centre*, Cairo, June 1978.
6. Wibulswas, P. and Kiatsiriroj, T. (1979) Evaluation of Solar Water Heaters with Evacuated Tube Collectors. *International Symposium on Solar Energy for Development, Japan Industrial Technology Association*, Tokyo, February, 1979.
7. Maung Nay Htun and Aftab, M.P. (1976) A Study of the Efficiency of Various Designs of Solar stills for Producing Potable Water, *J. Sci. Soc. Thailand* **2**, 22-34.
8. Pohom, A. and Wibulswas, P. (1978) A Stationary Solar Still. *Seminar on Solar Energy and Applications*, Technological Promotion Assoc. and King Mongkut Institute of Technology Thonburi, Bangkok, December 1978.
9. Exell R H.B. (1979) Direct Uses of Solar Energy Suitable for Rural Areas, *Seminar-Workshop on Agricultural Engineering*, National Research Council of Thailand, May 1979.
10. Exell, R.H.B. (1978) Free Convection Rice Dryer, *RERIC Newsletter*, AIT, Bangkok, October, 1978.
11. Tongprasert, M. (1978) Solar Rice Dryer—a Forced Convection Type. *Regional Solar Drying Workshop*, Manila, October, 1978.
12. Faculty of Engineering, Chulalongkorn University (1979) Research and Development on Energy, National Research Council of Thailand & East-West Center, Pattaya, March 1979.
13. Jarimopas, B. and Exell, R.H.B. (1976) Development of Solar Powered Refrigerator, Thesis No. 1098, AIT, Bangkok.
14. Chantavorap S. and Rajanaprakarn (1978) Solar Pumps. *Seminar on Solar Energy and Applications*. TPA-KMIT Thonburi, Bangkok, December 1978.
15. Panyakeow, S. (1978) Experimental Study on Electrical Properties of Contacts between Metal and Silicon Wafers. *Proceedings of 1st EE conference*, Bangkok.
16. Srisomwong, D., (1979) EGAT's Activities on Non-conventional Renewable Energy Resources, *Workshop on Solar Energy and Rural Development*, National Research Council of Thailand & East-west Center, Pattaya, March 1979.
17. Tanmitr K. (1978) D.C. Generators for Wind Turbines, *Seminar on Solar Energy and Applications*, TPA-KMIT Thonburi, Bangkok, December 1978.
18. Public Health Department (1979) Promotion of Biogas Activities among Public, *Workshop on Energy and Rural Development*, National Research Councol of Thailand & East-West Center, Pattaya, March 1979.
19. La Rivière, J.W.M. (1977) Microbiological Production of Methane from Waste Materials *J. Sci. Soc. Thailand* **3**, 5-13.