

The Potential Assessment of Renewable Energy Utilization in Thailand

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1. Overview

The economic expansion in Thailand has transformed the country from an agricultural-based subsistence economy into a semi-industrialized economy in the past two decades. The transformation has resulted in a rapid increase in the energy demand. The shift from an agriculture based economy to an industrial one and an envisaged rapid industrial growth are likely to push up the country's energy demand. It is, therefore necessary to properly plan for the future energy demands of the country and implement suitable strategies, well in advance, to avoid supply shortages in future.

In the forthcoming 21st century, the most important worldwide problem will be the environment. Utilization of fossil fuel is detrimental to the environment, causing the greenhouse effect and acid rain. Nuclear waste is a major problem for which there seems to be no solution in the immediate future. It is clear that our standard of living is directly affected by energy production, which is also a significant portion of the world's gross output. Searching for the alternative energy, like renewable energy to replace conventional energy, has become an important issue.

2. Energy Situation In Thailand

Thailand is a fast growing economy. During the recent past Thailand has achieved one of the highest economic growth rates in the Asian and Pacific region. As a direct consequence of rapid economic growth, the energy consumption in different sectors has increased rapidly.

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During the 1988–1997 period, the energy demand has grown by an average of about 9.3 percent annually.

The total final energy consumption in Thailand is usually disaggregated into 4 sectors, namely, industry, transportation, agriculture and residential & commercial. During 1988–1997, the transportation sector has been the largest consumer of energy with a growth rate of 10.7 percent in the final energy consumption. The final energy consumption growth rates for the rest of the sectors : industry, residential & commercial and agriculture sectors have been 11.9, 6.3 and -0.21 respectively. Fig 1 shows the final energy consumption by each sector during the same period.

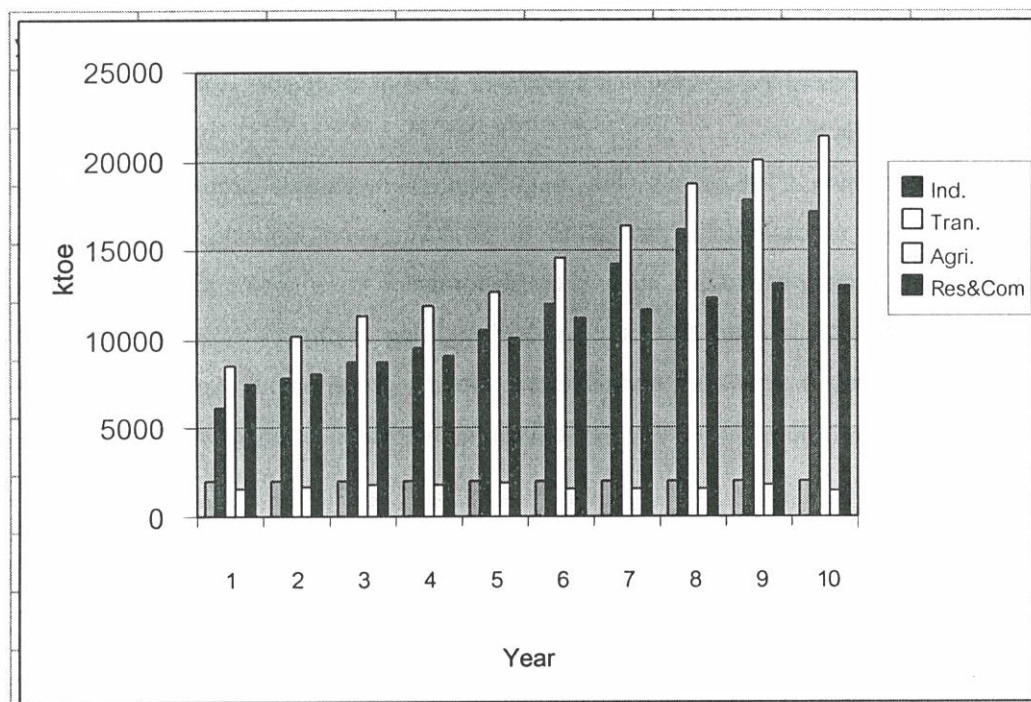


Fig 1 Final Energy Consumption In Thailand by Sectors during 1988-1997

In 1997 the modern energy consumption comprising of petroleum products, natural gas, coal and lignite and electricity rose 1.4 percent from the previous year. Amongst the commercial fuels, fossil fuels are the main sources of primary energy. In the year 1997 the

imported crude oil, petroleum products and coal accounted for 88.1, 6.8 and 4.9 percent, respectively of the total primary energy supply by energy sources. Renewable energy such as fuel wood, charcoal, paddy hush and bagasse share the 22.8 percent of final energy consumption in the same year.

3. Renewable Energy Utilization

Renewable energy utilization can provide energy in diverse forms, such as direct heat, liquid and gaseous fuels and electricity. There are many renewable energy resources available in the country. At present, approximately about 20 percent of the total energy demand comes from biomass which is mostly used in rural areas. The other renewable resources have been used in the areas that have suitable potential such as solar energy, microhydro, wind energy and geothermal energy respectively. In this paper a preliminary attempt to assess the potential of some renewable energy in Thailand has been made.

3.1 Wind Energy

Wind energy offers the potential to generate substantial amounts of electricity without the pollution problems of most conventional forms of electricity generation. Its environmental costs, mainly in the form of visual intrusion, are different from those of conventional electricity generation. The scale of its development will depend critically on the care with which wind turbines are selected and sited. Wind energy has been used for thousands of years for milling grain, pumping water and other mechanical power application.

Thailand is in the heart of the great monsoon belt of Asia. Surface winds go through a drastic seasonal reversal. The large scale winds may have a fairly constant seasonal direction with mean wind speed below 5 m/sec. About 5,800 wind pumps and 8 demonstration electricity generating wind turbines of 22 kW have been installed in Thailand up to the end of 1996.

King Mongkut's Institute of Technology and the Meteorological Department of Thailand conducted a study based on 17 years wind data (1966-1982) from 62 stations. The average wind speed is higher along the coast-line of the Gulf of Thailand and on the Indian Ocean coast. However, the mean speed in the inland over the north is very low. Table 1 shows the wind speeds and energy and power per unit area at some locations in Thailand.

3.2 Geothermal Energy

Thailand has more than forty medium-enthalpy geothermal resources scattered throughout the country, particularly in the North. In 1997, Thailand was expected to produce approximately 12 million kWh of electricity from geothermal resources, equivalent to an annual oil saving of 3 million litres. Geothermal heat is also used in drying agricultural products and in absorption refrigeration systems. This is equivalent to thermal energy from crude oil of 5 million litres annually.

Table 1 Average Wind Energy and Power per Unit Area at Some Locations in Thailand

Station	Energy per unit area (kWh/m ²)	Power per unit area (w/m ²)	Power per unit area (exclude calm) (w/m ²)
Chiang Rai	57.35	6.54	16.69
Chiang Mai	77.10	8.80	19.11
Nakhon Phanom	56.48	8.59	14.35
Khon Kaen	62.85	7.17	13.04
Nakhon Sawan	176.95	22.73	34.66
Ubon Ratchathani	210.28	24.09	35.54
Nakhon Ratchasima	498.56	5.69	11.49
Bangkok	108.88	12.38	19.54
Hua Hin	145.13	18.12	27.18
Surat Thani	522.00	6.13	13.02
Phuket	384.30	49.49	80.55
Songkhla	371.13	55.32	71.18

3.3 Biomass Energy

Biomass is the primary fuel consumed in rural areas of developing country including in Thailand and it contributes about 20 percent of the final energy consumption in the country. The main biomass resources include fuelwood, agricultural residues and animal dung. An attempt to estimate the available amounts of the three biomass resources for energy applications is made in the following subsectors.

3.3.1 Fuelwood

Fuelwood accounts for the major energy consumption in the residential sector particularly in the rural area. Rural area households used fuelwood mainly for cooking. Most of the fuelwood production in Thailand is found in the north and the north-east of the country. Table 2 shows the annual fuelwood supply potential in Thailand. The total estimated amount of fuelwood available in 2000 is 28.3 million cubic meters. With an annual average bulk density of 500 kg/m³, average calorific value of 17 MJ/kg, the potential energy available from fuelwood can be estimated as :

$$\begin{aligned} \text{Potential Energy from fuelwood} &= 28.3 \times 10^6 \text{ m}^3/\text{yr} \times 500 \text{ kg/m}^3 \times 17 \text{ MJ/kg} \times (2.273 \times 10^{-8}) \\ &\quad \text{ktoe/MJ} \\ &= 5,468 \text{ ktoe} \end{aligned}$$

Table 2 Annual Fuelwood Supply Potential In Thailand

Unit : Million cubic meters

	1983	2000
National reserve forests	6.7	5.7
Farmland	8.8	9.6
Other		
- Mangrove	2.7	2.6
- Wood industry waste	4.5	3.5
- State plantations	0.6	0.7
- Pararubber	3.4	4.2
- Orchards	1.8	2.0
Sub total	13.0	13.0
Total	28.5	28.3

3.3.2 Charcoal

The data on the amount of fuelwood used for charcoal making was not available. In the present study, using the time variation (1988-1997) of charcoal

consumption in Thailand, an attempt was made to fit a time trend curve (Fig 2). The following fit was obtained :

$$X_{\text{charcoal}} = 2,558.5 + 240.05t ; R^2 = 0.939$$

where $t = 1$ for 1988

The projected charcoal consumption for 2000 using the above regression fit is 5,439 ktoe. However, in view of the fact that charcoal is a preparation inefficient operation and fuelwood availability is limited, these values may not be achieved and we have taken a realistic value of 4,700 ktoe for 2000

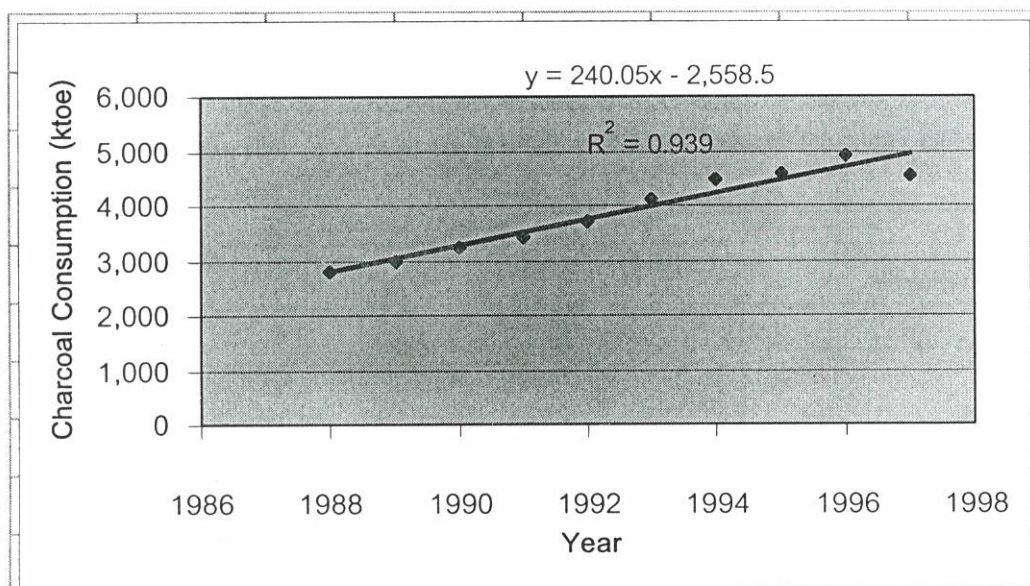


Fig 2 Time Variation of Charcoal Consumption In Thailand

3.4.3 Agricultural Residues

Crop residues are the plant materials that are left in the field or the agro-based industries after extracting the main crop produce. Crop residues can be in form of straw, stalk, husk, leaves, fibrous material, roots and other parts of the plant material. The main

agricultural crops providing agricultural residues for energy applications include rice, sugarcane, groundnut, cotton, maize and cassava. The residue availability can be estimated on the basis of the crop production provided that the residue to crop ratio is known. The agricultural residues may have several other completing applications, use as fodder being the important one. Moreover, it may not be possible to collect and store all the residues produced. Thus for a realistic estimation of the amount of agricultural residues available for energy applications, it is necessary that appropriate factors are introduced for estimation of potential availability of agricultural residues. In other words, the energy availability from agricultural residues can be estimated as :

$$\begin{aligned} \text{Energy from agri-residues} = & \sum_{i=1}^I (\text{crop production})_i * (\text{residue to crop ratio})_i * \\ & (\text{collection efficiency})_i * (\text{factor accounting for other} \\ & \text{application}) * (\text{storage fraction}) * \text{calorific value} * \\ & (2.273 * 10^{-8}) \text{ ktOE/MJ} \end{aligned}$$

The estimated potential of primary energy which can be provided by crop residues is shown in Table 3. Rice husk and bagasse obtained from rice and sugar cane respectively, are two very important biomass besides fuel wood. They are the main crop residues in Thailand. About 7 percent of final energy comes from rice husk and bagasse. The land area used for rice cultivation, which totals more than 9.6 million hectares, is capable of producing 20 million tons of paddy per year and about 5 million tons of rice husk can be obtained. The total production of sugar cane in Thailand is about 48 million tons per year

It may be noted that in Table 3 only five agri-residues have been considered. In actual practice, large amounts of other agri-residues are available (such as paddy, straw, cassava) which can be effectively to use for energy purpose with some effects. The additional potential which these agri-residues can be used is about 5,000 ktOE.

Table 3 Estimated Availability Potential of Some Agri-residues In Thailand

Crop residues	Available potential (ktoe)
Rice husk	629
Sugarcane	2,613
Groundnut	8.5
Cotton	52.2
Maize	1,332
Total	4,635

3.5 Biogas Generation

A biogas unit is an asset to a family. It produces good manure, clean fuel and improves sanitation. Biogas production is a microbial process. All microbes involved in biogas production grow in the absence of air or oxygen. For biogas generation, animal and human wastes such as cow dung, buffalo dung, urine, poultry droppings free from litter, other livestock waste, night soil and so on are used as feedstocks to biogas plants. There are a large number of animals in Thailand with dung availability estimated at 51 Mt per year and about 8 Mt of human waste.

Animals which provide dung for biogas generation include buffalo, cattle, swine, dairy cow, pig, goat, sheep, duck and chicken. The dung availability can be estimated on the basis of the number of animals and it may not be possible to collect and confine all the dung produced. Thus for a realistic estimation of the amount of dung available for energy applications, it is necessary that appropriate factors are introduced for estimation of potential availability of biogas. Twenty-five kgs of dung can produce 1 m³ of biogas. Table 4 shows the estimated potential of biogas generation in Thailand :

$$\begin{aligned}
 \text{Biogas potential} &= \sum_{i=1}^I [(\text{dung production}) * (\text{dung availability per day}) * (\text{collection efficiency}) * \\
 &\quad (\text{confinement fraction}) * (20 \text{ MJ/m}^3 \text{ of biogas}) * 365] / (25 \text{ kg/m}^3) * \\
 &\quad (2.273 * 10^{-8} \text{ ktoe/MJ})
 \end{aligned}$$

Table 4 Estimated Potential of Biogas Generation In Thailand

Sources	Biogas generation potential (ktoe)
Buffalo	148.7
Cattle	162.0
Dairy cow	2.9
Pig	50.3
Goat	0.9
Sheep	1.1
Duck	1.0
Chicken	5.2
Human	61.3
Total	433.4

3.6 Solar Energy

Thailand is situated near the equator between latitudes 6° - 20° N and between longitudes 97° - 106° E. On an average, the country is blessed with a very rich sunshine throughout the year. The solar energy assessment of Thailand has been undertaken by King Mongkut's Institute of Technology Thonburi (KMUTT) and the Meteorological Department under the Renewable Non-conventional Energy Project directed by Department of Energy Development and Promotion (DEDP). The linear regression coefficients relating the global solar radiation and sunshine hour at 9 meteorological stations were obtained from existing relationship between these regression coefficients and station latitudes. The coefficients at 19 meteorological stations were subsequently obtained by linear interpolation and extrapolation using the established relationship of 9 reference stations. Estimated values of global solar radiation at these 19 meteorological stations were calculated by making use of the acquired regression coefficients and measured sunshine hour data. The average annual mean daily global solar radiation is about $4.5 - 4.7 \text{ kWh/m}^2 - \text{day}$ [7].

Many types of solar thermal systems have been developed in Thailand. About 30,000 square meters of solar collectors have been installed in Thailand till 1996. The primary application has been for water heating in residences, hotels and hospitals. About 2.25 million

liters of hot water is obtained daily from solar systems which is equivalent to 70 MWh. In this paper, an attempt has been made to estimate solar energy utilization potential in Thailand for domestic cooking and solar water heating.

3.6.1 Solar cooking

Thailand's population was 60.1 million in 1996 (with a growth rate 1.2 percent). The World Bank projected Thailand's population to increase from 56.3 million in 1990 to about 86.3 million by 2030 and estimated the number of households at about 19,094 thousand for the period 2010 [4]. The energy consumption in the residential sector mainly consists of cooking, water pumping and lighting. The following assumptions have been made in estimating the potential contribution of solar cooker which would meeting the domestic cooking energy demand in Thailand

(i) The projected number of households in Thailand in 2010 is 19,093,971. [4]

(ii) Average household size is 5 persons per household.

(iii) The useful energy requirement for domestic cooking is 3.15 MJ/person/day.

(iv) Only 10 percent of the households use solar cookers.

(v) The use of solar cooker meets 30 percent of useful energy requirement for domestic cooking

(vi) The average efficiency of energy utilization in domestic cook stoves is 30 percent.

Therefore, final energy substitution by solar cooker in a year

$$= [19,093,971 \text{ household} * 5 \text{ persons/house} * 3.15 \text{ MJ/person/day} * 0.10 * 0.30 * 365 \text{ days/year} * (2.273 * 10^{-8}) \text{ ktoe/MJ}] / 0.30$$

The estimated potential of solar energy utilization by solar cookers in Thailand is about 249.5 ktoe for the year 2010.

3.6.2 Solar Water Heating

Solar water heaters can be used for providing hot water. In this paper, the potential of solar water heater is separated into two groups : (i) household and (ii) hotels in Thailand. The potential of energy substitution by solar water heating is estimated at 154 ktoe.

Among large buildings, hotels have more potential of solar water heating. Thailand has many hotels which have the potential for using solar water heaters. The number of rooms in Thai hotels was about 51,400.[10] The estimated potential of final energy provided by solar water heating in Thai hotels is 2.05 ktoe.

The following assumptions have been made for estimating the potential contribution of solar water heater in the residential sector in Thailand.

- (i) The projected number of households in Thailand in 2010 is 19,093,971.[4]
- (ii) Average household size is 5 persons per household.
- (iii) The water requirement for person per day is 30 liters per day at 40° C.
- (iv) Assume 15 percent of the household use solar water heater.
- (v) Only 3 months per year of the household use solar water heater.
- (vi) Specific heat capacity of water is 4.2 KJ/kg° C.
- (vii) The average efficiency of energy utilization in domestic is 30 percent.

Therefore, final energy substitution by solar water heater per year is

$$= [19,093,971 \text{ household} * 5 \text{ person/household} * 30 \text{ liters/person/day} * 0.15 * 90 \text{ day/year} * 0.0042 \text{ MJ/kg}^\circ \text{C} * 25^\circ \text{C} * (2.273 * 10^{-8} \text{ ktoe/MJ})] / 0.60$$

Also, for the solar water heater in hotels the assumption made is as follows

- (i) The total number of hotel's room in Thailand is estimated at 51,400 with a growth rate of about 5 percent. The estimated number in 2010 is 112,200.
- (ii) The average hot water demand for each hotel room is 40 liters per day at 60° C.
- (iii) The average yearly load factor is 0.7
- (iv) Solar energy will provide 25 percent of the total useful energy demand for water heating in Thai hotels in 2010.
- (v) The average efficiency of water heating in hotels with conventional fuels is 60 percent.

Therefore, final energy provided by solar water heater in hotels in a year is

$$= [112,200 \text{ room} * 40 \text{ liters/room/day} * 0.70 * 0.25 * 0.0042 \text{ kJ/}^{\circ}\text{C} * (60-15^{\circ}\text{C}) * 365 \text{ day/year} * (2.273 * 10^{-8} \text{ ktoe/MJ})] / 0.60$$

4. Conclusions

The results of potential assessment of renewable energy in Thailand show that energy can be obtained from fuelwood and charcoal are 5,468 and 4,700 ktoe respectively By the year 2000, agri-residues can provide 4,635 ktoe and biogas generation can meet energy demand of 433 ktoe. Solar energy also has a huge potential for example about 250 ktoe from solar cooking and 156 ktoe from solar water heating. ◇◇

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