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Wind Energy in Thailand to Enhance Energy Security: Potential, Status and Barriers

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Abstract – *The paper reveals the potential, status and barriers of wind energy in Thailand. With the growing concerns on energy security, green house gas (GHG) emission and consequent climate change, renewable energy sources have become attractive option for electricity generation around the world. The current power generation pattern in Thailand is not secured and sustainable as a result of country's heavy dependency on imported fossil fuels. Unlike conventional fossil fuels, wind energy is by large an indigenous power source with no fuel cost, no geo-political risk and no supply dependency that come with imported fuels. And also the decreasing cost of wind energy makes Thailand to think up its energy strategy and to include wind energy as one of the promising alternatives. The paper concludes that Thailand has not utilized wind energy resources anywhere near to its potential and there are plenty potentials and possibilities for electricity generation from wind energy.*

Keywords – Climate change, energy security, environmental benefits, renewable energy, wind energy.

1. INTRODUCTION

Thailand has seen a steady growth of electricity consumption, averaging at 7.12%, within the last five years. Though Thailand has been able to supply whatever amount demanded so far, the current power generation pattern is not secured and sustainable due to heavy dependency on imported fossil fuels. Electricity generated from renewable energy sources merely contributes 1% in total generation mix. The government targeted to raise the share of renewable energy from 1% in year 2004 to 8% by the year 2011. This means that around 1900 MW of new generation from renewable, by 2011, will have to be met by renewable and with estimated contribution of 100 MW from wind power.

Thailand is located in the Southeast Asia. It extends from 6ºN to 21ºN latitude and from 97ºE to 106ºE longitude. It enjoys a tropical climate and dominated by two major seasonal winds, namely northeast and southwest monsoons. The northeast monsoon flows from China in winter and lasts from November to mid- March. The southeast monsoon flows from the Indian Ocean in summer and lasts from mid-May to September. The onset of monsoons may vary to some extent. The climatic differences are mainly due to the influence of seasonal monsoon winds and regional topography. Northeast monsoon normally brings cold and dry continental air mass, so the temperature during this season is generally the lowest in a typical year. On the other hand, the southwest monsoon brings warm and very humid oceanic air mass.

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2. WIND ENERGY POTENTIAL IN THAILAND

Although several studies and measurements have been undertaken for a number of years by meteorological stations, few measurements have been made with the purpose of assessing the wind power potential [1]. The first study on the assessment of wind energy was done in the Chao Phraya Delta and the Mekong Region with the objective of surveying potential of wind energy to operate irrigation pumps [2]. Another study for the availability of wind energy for water pumping was also carried out in [2]. These studies encompass the surface wind which limits the potential to small-scale wind turbines. Few more studies were carried out in early 1980s by researchers at Asian Institute of Technology (AIT) and at the Meteorological Department of Thai Ministry of Communications. The studies involved an analysis of surface and upper-air wind records spanning several decades. The overall conclusion was that mean wind speeds in most parts of Thailand were rather modest, ranging (at 10 m height above ground level) from around 2 m/s in the northern part of the country to up to 4 m/s at some locations on the coast.

According to a report on wind resource assessment of Thailand done by the Department of Energy Development and Promotion (DEDP) in 2001, there are wind potent locations with an annual average wind speed of 6.4 m/s or higher at 50 m height. These locations are influenced by the monsoons and are located along the eastern coastline of the southern part of Gulf of Thailand and in mountains of west and southern regions of Thailand [3]. A fair wind potent locations with an annual average wind speed of 4.4 m/s or higher are mainly located on west side of the Gulf of Thailand.

According to research carried out in [4], Gulf of Thailand is likely to be very attractive for small wind turbines in village power applications, with mean wind speeds at 30 m of 6.5-7 m/s. In low-lying areas, the small-scale wind class is good with typical mean speeds

at 30 m of 5 m/s. While in west-central Thailand, good winds are found on the mountain tops and ridges of the Tanem Range, where elevations reach a maximum of about 2000 m. The ridges of 1400-1600 m elevation to the southwest of Tak province have a favourable orientation with respect to the prevailing westerly wind direction, resulting in good winds as well. Access to these sites is probably very difficult however as the mountain slopes are steep and there are few roads and transmission lines. On the other hand there is a mountain pass at 700-900 m elevation to the west of Tak province which is traversed by a road and where the mean speed may reach about 6.5 m/s. Winds are poor throughout the broad valley to the east of Tak [4].

The mountains of Phang Hoe Range around Lomsak province in the east-central region of Thailand are typically 900-1100 m in elevation, though a few peaks reach 1600 m. The winds on exposed features are generally good (7.0-8.0 m/s), with ridges oriented northwest-southeast having the best wind resource relative to elevation. A prime example of such a ridge is the one lying half-way between Lomsak and Chaiyaphum. A fair to good wind resource for small wind turbines exists in the broad plains around Chaiyaphum and Selaphum [4]. Wind potential in Northern Thailand (around Chiang Mai and Chiang Rai) is generally poor. Although the range is mountainous (especially to the west of Chiang Mai), the wind potentials is at best described as “fair” to “good” on even the tallest mountain, the 2600-meter Doi Inthanon [4].

Thai Ministry of energy has estimated the technical and commercial potential of renewable energy, which are given in Table 1. It has been shown that wind energy utilized targeted energy from wind is far behind the technical potential. The government has targeted to install at least 6% of total potential of wind energy by 2011.

According to estimates prepared for the World Bank Asia Alternative Energy Program [4], it is interesting to note that 64% of the rural population of Thailand live in areas with a moderate wind resource (4 -5 m/s) and can be served by small wind turbines.

The present status of wind energy development in Thailand is in very primitive stage with total grid connected generation of about 150 kilowatts. The two main applications of windmills in Thailand are water pumping for household uses in remote areas and electricity generation. Wind energy is used to a limited extent also for electricity generation in the islands of southern region where mean wind velocity is higher. The “good” potential wind sites are the high mountains of the north and areas in the south that are exposed to monsoons all year that includes the western coastline of the southern peninsular (Laem Promthep, Phuket) and the eastern coastline from Laem Talumpuk, Pakpanang District, Nakornsrithammarat to Laem Tachi, Pattani [7]. Figure 1 shows the wind map of Thailand and Table 2 shows wind potential of some provinces in Thailand.

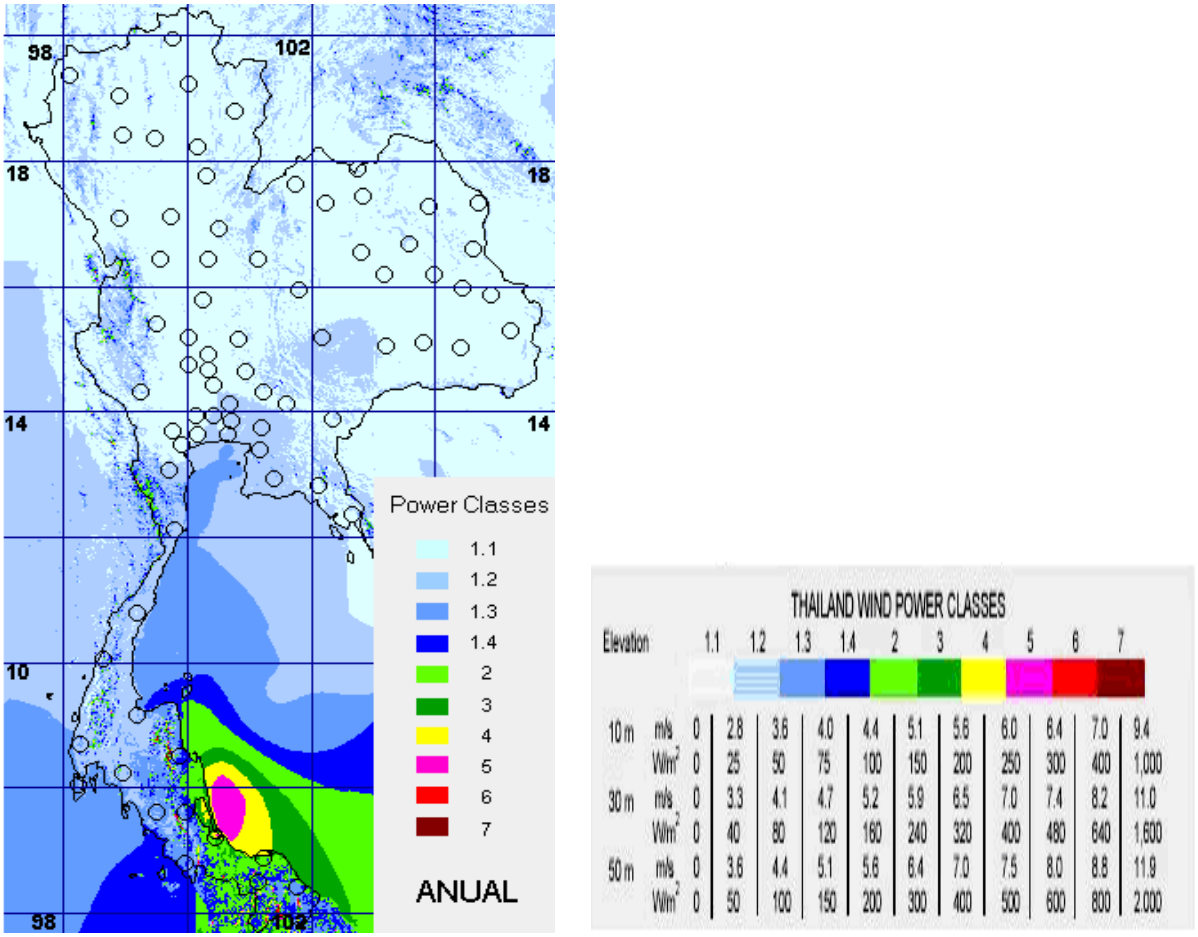

Fig. 1. Wind map of Thailand.
Source: Department of Alternative Energy Development and Efficiency (DEDE).

Table 1. Estimated renewable energy potential in Thailand.

Type	Potential (MW)		Government target by 2011 (MW)
	Technical	Commercial	
Biomass	7,000	>4,500	1,140
Solar PV	>5,000	?	250
Wind	1,600	?	100
Micro and Mini Hydro	700	350	350
Total	>14,000	>4,800	1840

Source: http://www.eppo.go.th/admin/moe-workshop1/index.html.

Wind Energy in Neighboring Countries

Based on a World Bank study, there are good to excellent wind resource areas for large-scale wind generation that can be found in the mountains of central and southern Vietnam, central Laos, and central and western Thailand, as well as a few other locations.

Opportunities for village wind power are considerably more widespread because small wind turbines are able to operate satisfactorily at lower wind speed. Areas of good to excellent wind resource for village power are predicted in east-central Thailand, western and southern Cambodia, the northern and coastal southern Malay Peninsula, south central Laos, and a large proportion of central and southern Vietnam as well as coastal areas of northern Vietnam. The study estimates that about a quarter of the rural population of the four Southeast Asian countries live in areas showing good to excellent wind speed where small-scale wind energy is possible [5].

3. ENERGY SECURITY SITUATION IN THAILAND

Due to increasing economic growth in Thailand the domestic energy reserves will not be able to adequately accommodate increasing demand of the country. As of now, Thailand has to depend largely on imported energy at a considerable cost each year. In 2002, the energy consumption in Thailand accounted for a value of about 800 billion Baht (or about US$ 20 billion), which was about 14% of the Gross Domestic Product (GDP), and the value of imported energy was greater than 300 billion Baht span [8].

If the trend of Thailand's energy consumption remains the same as that in the past and given the economic growth rate of 5% per year, it is forecasted that in 15 years, or by 2017, the value of energy consumption will increase from 0.78 trillion Baht to 2.1 trillion Baht as shown in Figure 2 and that the dependency on imported energy will inevitably increase accordingly.

The high dependency on imported energy will make Thailand at risk of energy supply disruption and volatility of energy prices, apart from a substantial foreign currency loss for the imports of energy.

Furthermore**,** Thailand is a net energy importer with over 57 percent of energy needs being met through imports, primarily oil. Indeed, 92 percent of Thailand's oil requirements were met through imports in 2001.

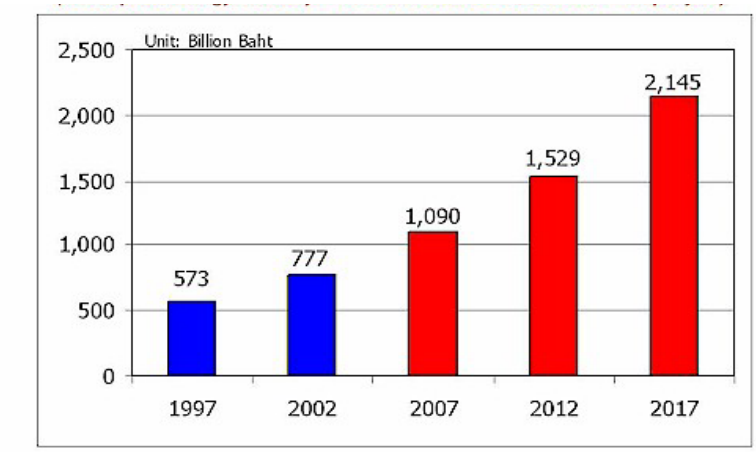

Fig. 2. Forecasted value of national energy consumption in the future. ***Assumption: Energy Elasticity = 1.4:1 and Estimated GDP Growth Rate = 5% per year).***
Source: Energy Strategy: Energy for Thailand Competitiveness, [8].

Table 2. Wind potential in some provinces of Thailand.

Area	location	Wind speed (m/s) at 50 m ground	Wind power (w/m^2) at 50 m ground
Tai Rom Yen National Park	Nakhomsrithammarat	8.00 -11.90	600-2,000
Khao Luang National Park	Nakhomsrithammarat	8.00-11.90	600-2,000
Khao Pu-Khao Ya National Park	Pattalung	8.00-11.90	600-2,000
Wang Chao National Park	Tak	8.00-8.80	600-800
Doi Intanon National Park	Chiang Mai	7.00-7.50	400-500
Gaeng Grung National Park	Surat Thani	7.00-8.00	400-600
Pa Nombenja Mountain	Khrabi	8.00-8.80	600-800
Ranod District	Songkhla	7.00-7.50	400-500
Song Khla Lake	Songkhla	7.50-8.00	500-700
Ta Chi Cape	Pattani	7.00-7.50	400-500
Hua Sai District	Nakhomsrithammarat	6.40-7.00	300-400

Source: Electricity Generating Authority of Thailand (EGAT).

Table 3. Wind Studies of Neighbouring Countries of Thailand.

Characteristics	Cambodia	Laos	Thailand	Vietnam
Poor: < 6m/s				
Land area : Km^2	175,468	184,511	477,157	197,342
% of total area:	96.4	80.2	92.6	60.6
MW potential:	NA	NA	NA	NA
Fair: (6-7)m/s				
Land area : Km^2	6,155	38,787	37,337	100,361
% of total area:	3.4	16.9	7.2	30.8
MW potentia:	24,620	155,148	149,348	401,444
Good: (7-8)m/s				
Land area : Km^2	315	6,070	748	25,679
% of total area:	0.2	2.6	0.2	7.9
MW potential:	1,260	24,280	2,992	102,716
Very Good: (8-9)m/s				
Land area : Km^2	30	671	13	2,187
% of total area:	0.0	0.3	0.0	0.7
MW potential:	120	2,684	52	8,748
Excellent: >9m/s				
Land area : Km^2	0	35	0	113
% of total area:	0.0	0.0	0.0	0.0
MW potential:	0	0	0	452

Source: Ministry of Energy (MOEN), developed by World Bank.

Figure 3 show that Thailand has a theoretical potential to exploit "other means of primary energy" production strategies which have already provided considerable contribution to total energy demand in countries like Philippines.

Therefore domestic renewable energy resource development should be accelerated in order to reduce dependency on oil import and to ensure the national energy supply security and sustainable energy development.

The peak demand increases nearly three folds between the years 1997 and 2016. Figure 4 shows the peak demand and total energy demand for the years 1997-2004 and the forecasted peak demand and total energy demand for the years 2005 to 2020. Though the forecasted peak demand for year 2005 was 21644 MW, according to the Electricity Generating Authority of Thailand, the peak demand in 2005 was only 20,538 MW, which was recorded on April 26, 2005 at 2 pm.

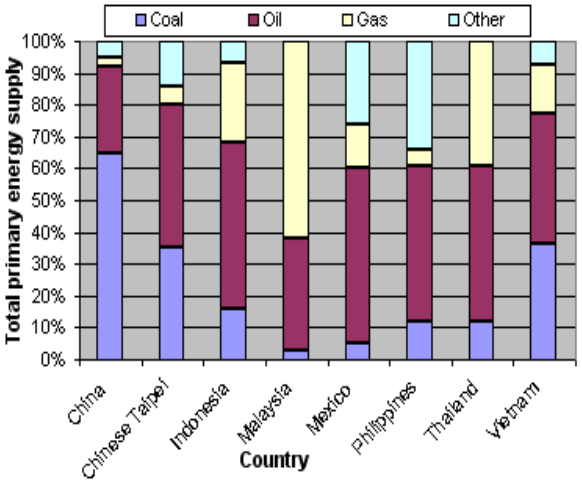

Fig. 3. Profile of total energy supply in APEC developing economies, 2001.
Source: Report of Kyoto Protocol and APEC Economics, [6].

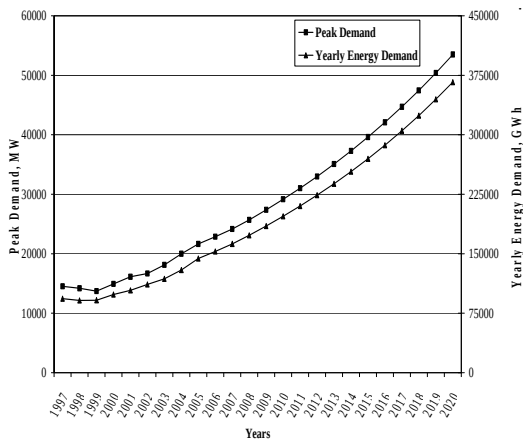

Fig. 4. Thailand's peak demand forecast [16].

Currently, Thailand imports electricity from Laos and importing electricity from Myanmar is also under negotiation. As far as Thailand is concerned, energy security is in question with approximately 7904 MW of electricity projected to be imported from 2011 to 2020, as explained in Table 4.

Table 4. Electricity supply Management, unit is in MW.

Year	New Capacity in Thailand	Imported electricity	Total
2011	0	597	597
2012	1470	0	1470
2013	2205	710	2915
2014	1470	0	1470
2015	1470	460	1930
2016	0	600	600
2017	1700	1337	3037
2018	1195	1400	2595
2019	1470	1400	2870
2020	1195	1400	2595
2020	1195	1400	2595

Source: Ministry of Energy (MOEN).

4. WIND ENERGY STATUS IN THAILAND

Various studies in wind have been conducted in Thailand and some of them are listed below:

- In 1975, average wind velocity in Thailand was investigated by National Energy Policy Office (NEPO) using data from Thai Meteorological Department
- In 1981, database for average wind velocity in Thailand at 10 meter height was developed by Electricity Generating Authority of Thailand (EGAT) and King Mongkut's University of Technology Thonburi (KMUTT)
- In 1994, wind map of wind velocity and wind power at 10 meter height was developed by KMUTT sponsored by USAID.

It has been found that Phuket is one of the suitable locations for the installation of Wind Turbine Generator (WTG) in Thailand. Some specific sites of Phuket Island have been measured and evaluated by EGAT, the results show that the monthly wind speed varies from 4.0 to 6.1 m/s. This site is good for installation of large wind turbine generation. Furthermore, many parts of the peninsular have the accessible roads for huge mobile crane and 33 kV distribution line of Provincial Electricity Authority (PEA) exists for grid connection.

As a part of the EGATs WTG demonstration projects, three wind turbine generators were installed in Promthep Alternative Energy Station, Phuket. Two of them are 10 kW units that are used for battery charging purpose since 1993 and a 150 kW unit was connected to the distribution grid since 1996. Figure 5 shows the location of 3 WTGs in Phuket.

Table 5 shows the wind turbine installation around Thailand, their installed capacity along with some details.

Fig. 5. 150 kW WTG in Phuket.

Table 5. Current status of wind energy in Thailand.

Sectors/Manufacturers	Wind (kW)	Description
EGAT	150	100% imported
Ratchaburi Energy, RE	5	Vertical axis, Technology transferred, Low wind speed.
Wind Win Tech. Co. Ltd	3	Horizontal axis, 70% imported, 30% local made, Low wind speed
SCI Electric Manufacture Co. Ltd	3.5	Vertical axis, Local made, Technology transferred, Low wind speed
SCI ElectricManufacture Co. Ltd	1	100% local made, Low wind speed

5. BENEFITS OF WIND ENERGY IN THAILAND

EGAT had installed 150 kW WTG in Phuket peninsula. This facility of electricity generation from wind energy was connected to the grid of Provincial Electricity Authority (PEA) in 1996. The main purpose of EGAT to establish this project is to demonstrate the electricity generation from wind energy to gain experience for identifying the best possible technologies and types of WTG in line with the speed and direction of wind varied from seasonal changes. Therefore, 150 kW WTG will be the basis information to use for the future experiments. Thus, it shows that WTG is economically and enviromentally beneficial to Thailand. As of now, there are a number of isolated and grid connected projects of WTG underway.

Economic Benefits

150 kW wind turbine generator (WTG) which supplies 250,000 kWh to the distribution grid every year is a success story of wind power generation in Thailand. The WTG technology for grid connected is easily to operate and has the low cost in maintenance. The 150 kW WTG is automatic operated in 24 hours, which depend on wind speed and wind direction. In general, 16.13% frequency of NW wind direction with an annual average wind speed of 5.2 m/s occurred in Phuket. Table 6 shows economic parameters of 150 kW WTG in Phuket. The calculations were made with 9.5% discount rate without subsidy.

Table 6. Economic Parameters of 150 kW WTG in Phuket Islands.

Total investment cost	Baht 13,100,000
Electrical energy generated	197,000kWh/yr
Operation and maintenance	Baht 260,000/yr
Cost of generation	Baht 9.45/kWh
FIRR	14.0%

Source: Electricity Generating Authority of Thailand.

The WTG in Phuket shows that the cost of producing power from wind in Thailand is higher than producing power from conventional sources like fossil fuels, but most competitive with other renewable energy and also FIRR is quite good. Figure 6 shows the cost of energy by different renewable sources in Thailand.

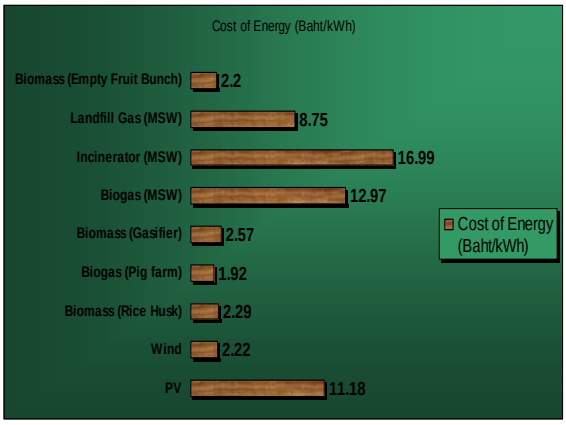

Fig. 6. Cost of energy (Baht/KWh).
Source: Energy for Environment Foundation

Hence, the good FIRR, low maintenance cost and the competitive cost of energy among renewable energy sources make the WTG economically viable in Thaialnd. As a result, EGAT has planned to install large WTG of about 750KW x 3 as immediate plan around existing WTG location at Phuket and more on the way.

Environmental Benefits

The four key greenhouse gases (GHGs) with global warming potential: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and hydrofluorocarbons (HFCs), are coming from five main sectors of Thailand: energy, industrial processes, agriculture, land use change, forestry and wastes. Among these, energy sector is the dominant one. Three studies have been undertaken on the national greenhouse gas (GHG) inventory and the potential for GHG mitigation in Thailand; namely 1) Thailand's National Greenhouse Gas Inventory, 1990 (Environmental Policy and Planning (OEPP), 1990); 2) Thailand's National Greenhouse Gas Inventory, 1994 (OEPP, 1994); and 3) National Clean Development Mechanism Strategy Study of the Kingdom of Thailand (Ministry of Natural Resources and Environment or MONRE, 2004). The results are summarized in Tables 7 and 8 respectively (Source: 1/ OEPP (1990); 2/ OEPP (2000); 3/ MONRE (2004).

Table 7. Past and projected net GHGs emission from five main sectors (Gg: 1000 tonnes = 1Gg).

GHGs	**1990**	**1994**	**1998**
CO_2	163,996	202,458	204,292
CH_4	57,695	66,598	79,537
N_2O	3,506	17,317	13,646
HFCs	NA	NA	136
Total	225,297	286,373	297,611
GHGs	**2000**	**2010**	**2020**
CO_2	202,610	268,722	414,938
CH_4	79,070	88,726	100,584
N_2O	15,063	17,771	18,507
HFCs	241	443	668
Total	296,984	375,661	534,697

Table 8. GHGs emission by sectors.

Sector	Percentage of CO_2 Emissions		
	1990	**1994**	**1998**
Energy	35.37	45.54	51.06
Industrial Processes	4.36	5.58	3.61
Agriculture	24.21	27.03	23.26
Land Use Changes	34.71	21.6	17.02
Waste	1.36	0.26	5.05
	2000	**2010**	**2020**
Energy	49.77	58.32	67.44
Industrial Processes	4.54	5.62	5.86
Agriculture	23.08	18.64	12.99
Land Use Changes	17.03	10.36	6.37
Waste	5.59	7.05	7.34

Source: MOEN.

Now, consider the targeted 100 MW wind turbine (by 2011), which can replace the same MW of power plant generated by fossil fuels. Therefore, certain amount of CO_2 produced by fossil fuels can be reduced as wind turbine is clean green energy technology.

Taking a reference of 150 KW wind turbine generator in Phuket, which generates 250,000 KWhr/year in average. That means, 100 MW wind turbine generator generates 166,666,666.7 KWhr/year.

In general, coal power plant (CPP) produces 800 - 1050 grams of CO_2 per kWhr, which includes manufacturing the generating equipment and processing the fuel. If we consider, CPP produces 1000 grams of CO_2 per KWhr, then we can easily find by how much CO_2 will be reduced by replacing with 100 MW wind energy.

In 1KWhr, coal produces 1kg of CO_2. In 166,666,666.7 kWhr/year, coal produces 166,666,666.7 Kg or 166,666.67 ton of CO_2.

Therefore, if 100 MW wind turbine generator is replacing the same capacity of coal power plant even with half of CPP plant factor then it will deduct 166,666.67/2 tonnes (88.335 Gg) of CO_2 per year. This ton of CO_2 reduction per year has high positive impact in the environment, locally and globally.

6. BARRIERS OF EXPLOITING WIND ENERGY IN THAILAND

The barriers in promoting wind energy or renewable energy in Thailand is summarized in Table 9.

Most of these barriers can be addressed by improvement in policies and regulations in renewable energy and energy efficiency. Amendment of policies and regulations should be done both in country level and regional level, to be more supportive towards the promotion of renewable energy and energy efficiency. Though some of the policies have been implemented by Thailand to achieve the target to increase the contribution of renewable energy source in generation mix by 8% and wind is expected to provide 100 MW by 2011.

7. POLICIES AND PLANS FOR RENEWABLE ENERGY DEVELOPMENT

The government has an established policy on New and Renewable Source of Energy Development and promotion. Under the 7th NESDP (1992-1996) the research and development, production and utilization of NRSE are promoted in the following areas [10]-[12]:

- The production of non-conventional energy technologies that are commercially viable and would better the quality of life in rural areas.
- The utilization of non-conventional energy sources such as solar energy, thermal energy and energy from agricultural and industrial residues, e.g. biogases, rice husk and municipal waste.
- The establishment of private energy plantations for the industrial production of fuel wood and charcoal as energy sources for rural areas.

Furthermore, measures that should encourage more widespread use of Renewable Energy Technologies include:

- Fiscal incentives (subsidies, grants or tax breaks)
- Guaranteed prices and markets for electric power produced by renewable energy based technologies
- Integrated planning considering renewable, research and development, information and education programs as well as encouragement of private sector participation.

In addition, rules and regulations on energy use and associated environmental standards may favour the utilization of Renewable Energy Technologies. Different mechanisms for the promotion of renewable energy sources (RES) and energy efficient technologies (EET) have been established by Thai government with one of target to reduce annual growth rate of energy consumption from 13% to 10% per year. Table 10 summarizes different types of mechanisms opted by the government [13]-[15].

Table 10. Mechanisms for the promotion of RES.

S.N	Mechanism	Objectives	Descriptions
1.	ENCON program	-Providing financial help and incentives -Public awareness -Research and development	Energy conservation program supports energy conservation and renewable energy technologies
2.	PP program	-Power purchasing from small producers-SPP, VSREPP.	Power purchase program develop to promote the use of domestic RES and EET to generate and sell power to grid.
3.	RPS	Promote the extensive use of available RES	Under RPS, power companies that wish to bid to supply power to EGAT must produce 5 % of their installed energy capacity from RES, otherwise pay a fine of 1.3 times the electricity fee produced from RES.

8. CONCLUSION

The Thailand government has a long established policy on renewable energy development. The fund known as ENCON provides financial incentives for Energy Conservation projects related to renewable energy research. The fund also supports development and public awareness promotion related to renewable energy in order to stimulate an investment in projects related to renewable energy and energy efficiency and to encourage banking community to provide loan facilities at low interest rates. Further the government has formulated and employed policies like SPP program, subsidy SPP program, VSREPP program.

However, further promotion is essential as the percentage of wind energy added to the national grid still lies in a very small percentage. Thus it's important for Thailand to implement sound policy measures in order to achieve its targets. Measures should be taken to increase awareness among the potential stake holders regarding the wind energy technology and to increase technical and human resource capability. By looking at the available potential on wind energy, it would be feasible to have a high wind power penetration in Thailand's electricity generation mix and enhance energy security.

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