Increasing Efficiency in Wind Energy Electricity Generating by Signal Processing from Wind Measuring Equipment on Wind Turbine for the Determination of Wind Direction

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***Abstract*—Wind energy is a type of clean energy which Thailand generates it for 299.17 MW. However, its problems found in Thailand are unconstant wind blowing and not high wind blowing speed. In Chaiyaphum province, an average wind blowing speed is 5.77 m/s throughout the year. Regarding the electricity generating of the wind turbine operation, there is a slow direction finding of the wind turbine due to its big size. (2.5 MW electricity generating per wind turbine). This has effect on ineffective operation in electricity generating. Natural condition of the wind involves change in wind direction. The wind turbine generating electricity also turns based on wind direction (90^o) for electricity generating. The wind turbine will stop electricity generating when the wind stops blowing. Also, the face of the wind turbine will stop based on the direction of the wind blowing through it in which it is inappropriate direction for electricity generating in the next round. The wind turbine has to waste the time in turning back to the normal wind direction (Turn around 180 degree take time 10 minutes). This study presents the determination of wind direction of the wind turbine by using standard deviation of direction signal from wind measuring equipment on the wind turbine. This study presented method results in the wind turbine to stop and waits for the wind in an appropriate position. Besides, it reduces the time of wind turbine turning to the wind direction. Also, it increases an opportunity for effective electricity generating.**

Keywords—Wind turbine; Wind direction; Signal processing; Standard deviation; Huge error

I. INTRODUCTION

ASEAN or The Association of Southeast Asian Nations has become to be "ASEAN Community: AC since 2015 operated under ASEAN Charter. All nation members must legally practice in accordance with ASEAN Charter rules and regulations. After forming the ASEAN community, there are many common ideas in various aspects such as politics and stability, society and culture, economy / trading / investment, including energy collaboration. Circulation energy is promoted by all nation members because it is clean and environmentally friendly making people have a better quality of life as well as having stable and sustainable energy [1].

The Ministry of energy, Thailand has reviewed 5 main energy plan preparation for 2015-2036 [2] which is consistent with the preparation of the National Social and Economic Development plan i.e. electricity generating power development, energy conservation, renewable and alternative energy development, natural gas procurement, and fuel oil managerial administration. According to the Alternative Energy Development Plan: AEDP 2015, it puts the importance on the promotion of energy production from renewable energy raw material existing in the country. This depends on potential, potential development, renewable energy production with appropriate technology and the development of renewable energy for common benefits in social dimension and environment to the community. Office of the Energy Regulatory Commission [3] is established to supervise and inspect operation of energy firms of the licensee. In fact, the renewable energy aspect purchases electricity of the renewable energy electricity plant for more than 6,000 MW. Renewable energy includes solar energy, bio-mass energy, bio-gas energy, and wind energy. All of these are part of the renewable energy used for generating electricity.

As a matter of fact, Thailand is located in the equator area where it is rather windy. The wind concerning with the climate in Thailand is seasonal wind called monsoon which changes its direction

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seasonally. Examples are summer monsoon, blowing in the line of south and southwest directions and cold season monsoon, blowing in the north and northeast directions [4]. Actually, effective electricity generating by wind energy depends on continuity, direction, and speed of the wind.

T. Senjyu et al. (2006) [5] The proposed method presents a control strategy based on average wind speed and standard deviation of wind speed and pitch angle control using GPC in all operating regions for WTG. Output power command is determined by approximate equation for windmill output using average wind speed, and standard deviation of wind speed is corrected by using fuzzy reasoning. Thus, in WTG using the proposed method it is possible to bring a stable operation for rapid change in operating point. In the simulations, despite rapid change of wind speed in below-rated wind speed and wind shear, output power leveling for all operating regions is well achieved by the proposed method.

L. Heping et al. (2013) [6] introduce a quantitative methodology that performs the interval estimation of wind speed, calculates the operation probability of wind turbine, and forecasts the wind power output. The technological advantage of this methodology stems from the empowered capability of mean and volatility forecasting of wind speed. Based on the real wind speed and corresponding wind power output data from an offshore wind turbine, this methodology is applied to build an ARMA–GARCH-M model for wind speed forecasting, and then to compute the operation probability and the expected power output of the wind turbine. The results show that the developed methodology is effective, the obtained interval estimation of wind speed is reliable, and the forecasted operation probability and expected wind power output of the wind turbine are accurate.

Therefore, the team of researchers decided to conduct a study on increasing efficiency in wind energy electricity generating by signal processing from wind measuring equipment on wind turbine for the determination of wind direction. Method of huge error was employed for finding inappropriate standard deviation and rejection of data. After that, making a plan to determine wind waiting direction for wind turbine electricity generating.

II. Related Theories

A. Standard Deviation

Standard Deviation (S.D.) is one of the most useful calculations to find the variability of data.

Standard Deviation formula

$$S = \sqrt{\frac{\sum (X_i - \mu)^2}{N}} \tag{1}$$

Where:

- s is sample standard deviation.
- x_i is represents each data value.
- Σ is sum of the data values.
- μ is a population mean.
- N is the count data values in a population data set.

B. Rejection of data

An analysis for finding an amount needed to collect data for many times and after that computing an average value for correctness. Sometimes, obtained results from data collection present a wrong value-too much or too little. Thus, it needs to have a method inspecting an abnormal value which must be deleted. Outliners (of value) refers to the value giving deviation more than 4 times of the standard deviation value. The second equation shows the value which is suspicious to be outliners and the third equation shows the value which is not.

$$\frac{|X_o - X_m|}{S_m} > 4 \tag{2}$$

$$\frac{|X_o - X_m|}{S_m} < 4 \tag{3}$$

Where:

- X_0 = Suspicious value
- X_m = An average mean score which the suspicious value is not taken into account
- S_m =A standard deviation value which the suspicious value is not taken into account

C. Conversion of wind power to be electricity energy

Operation principle of the electricity generating wind turbine. Where the windmill inspects wind speed to be more than 3 m/s for 3 minutes (consecutively), the wind turbine will turn to the wind direction. When the wind blows through the wind turbine, the wind power will make the propellers rotate and mechanical energy occurs. After that, the mechanical energy from the wind turbine spindle will be sent to the electricity generator and transformed to be electricity energy. An amount of obtained electricity depends on wind speed, length of the propeller, and location of the wind turbine.

D. System of wind turbines

Mode of operation in the wind turbine operating system show in Figure 1.

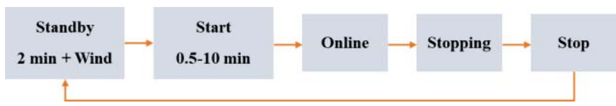

Fig. 1. Operating modes

- Standby -Wind turbines adjust to 75 degrees and wait for wind to start producing electricity
- Start - Adjust the direction of the Nacelle in the direction of the direction of the wind.
- Online - Electrical generating
- Stopping - Wind turbine start to stop
- Stop - Wind turbine downtime and adjust the blade 90 degrees

III. Experimental Method

1. Data used in this study was the project for electricity generating from wind power in Chaiyaphum province, Thailand. The electricity generation power was 2.5 MW per windmill (32 wind turbines around the area) (Figure 2).

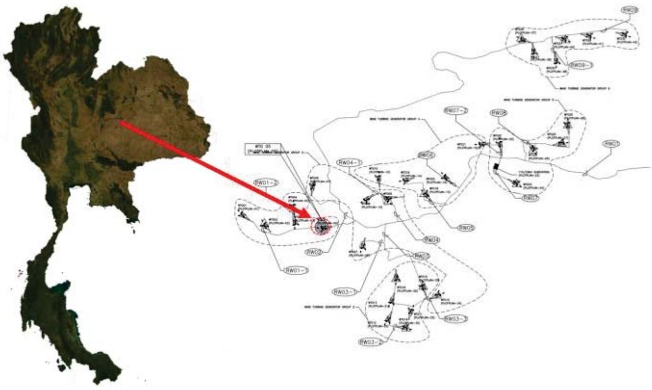

Fig. 2. Wind power in Chaiyaphum province, Thailand

2. This study used wind turbine data No. WTG05 valley surrounded by mountains and hills. Figure 3. Aerial cross-sectional photo of the WTG05 wind turbine which shows topographic traits and 539 msl height distance of the wind turbine.

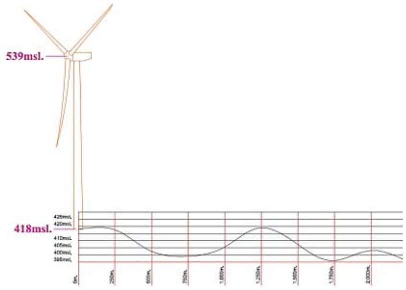

Fig. 3. Aerial cross-sectional photos

3. Step of the determination of wind waiting direction

Present wind data were compared to find if it was in the rejection of data. If not, the data were included to find a standard deviation value and determine the wind direction (Figure 4)

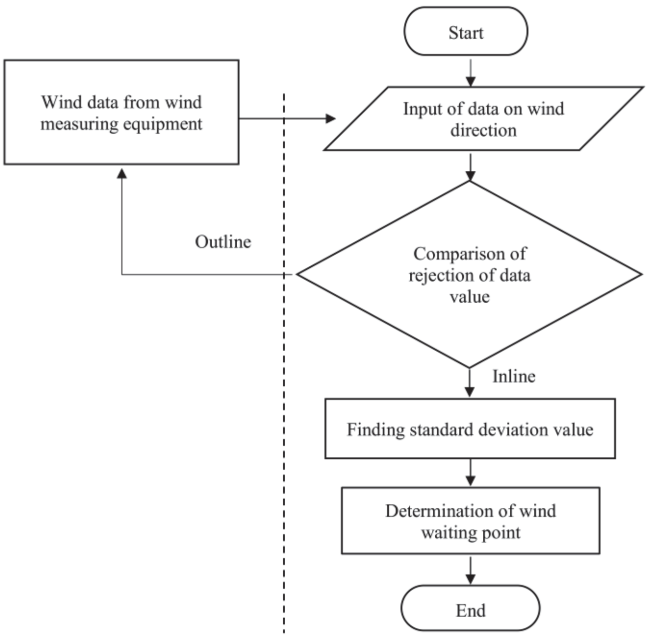

Fig. 4. A diagram on an analysis of wind data from the wind measuring equipment on electricity generating wind turbine

IV. Results of the Experiment

According to data collection from the WTG05 wind turbine on 1st July, 2017 (Real time) during 00.00-11.59 p.m. (9,707 data on time, wind speed, wind direction, Theoretical Active Power, and Wind turbine energy yield). On that day, there were 8 electricity generating rounds.

Data on direction of wind turbine used for finding a standard deviation value (Figure 5)

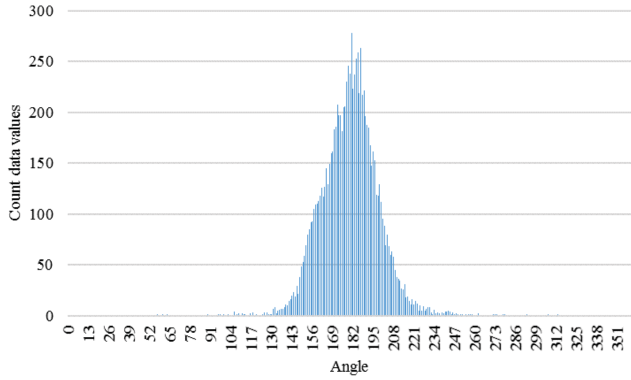

Fig. 5. Tendency of standard deviation value

Step on an analysis of wind data from the wind measuring equipment. Result of the rejection data value computation was ±2 then, it was used for finding standard deviation value started at 181° for finding appropriate wind direction of the wind turbine. Results of the comparison are shown in Table 1

TABLE I. A COMPARISON OF WIND WAITING DIRECTION AND EXISTING WIND DIRECTION STANDARN DEVIATION VALUE USING

No.	Time	Stop wind direction (°)	Difference in wind waiting direction (°)		Results of the comparison (°)	Decreased time (min)
			a	*b*		
1	03:00:01.27	229.15	63.99	48.15	15.84	0.89
2	14:47:09.60	153.29	18.41	27.71	-9.30	-0.52
3	14:58:30.09	209.51	57.22	28.51	28.71	1.61
4	15:14:07.65	188.79	32.57	7.79	24.77	1.39
5	15:53:18.54	171.67	6.24	9.33	-3.09	-0.17
6	16:14:48.14	211.88	54.38	30.88	23.51	1.32
7	17:06:56.12	262.68	86.05	81.68	4.37	0.24
8	17:32:38.48	231.08	48.10	50.08	-1.98	-0.11
The total results on different methods					**82.84**	**4.64**

a = The difference in wind waiting direction / production round, from the wind waiting direction which the turbine stopped until next round of production

b = The difference in wind waiting direction from standard deviation value using until the next round of production

According to Table 1, it was found that the determination of wind waiting direction from standard deviation value using had an effect on the wind turbine stop in the wind waiting direction which was more appropriate than the wind waiting direction per normal production round. The angle distance in rotation to the wind direction had less value. There was decreased time in rotation to the wind direction when compared with the natural method. Based on are analysis of data gained from the wind turbine WTG05 on 1st July, 2017, there were 8 rounds of electricity generating. In the case of the day having increased rounds of electricity generating due to discontinued wind blowing, it saved time in rotation for finding wind direction. This had an effect on increased electricity generating.

Increasing efficiency in wind energy electricity generating by using signal processing from wind measuring equipment on wind turbine was compared with the generating power for wind direction determination (wind turbine WTG05, 1st July, 2017), there were 8 rounds of electricity generating. This helped save time for the rotation to the direction of electricity generating of the wind turbine (4.64 minutes) and it was able to increase electricity generating power for 63.48 kW.

V. Conclusions

Normally, the electricity generating power is controlled the wind turbine. It will rotate due to the wind and stop to wait for the wind blowing to the determined direction. The wind turbine will have to rotate for direction adjustment to find the wind and start to generate electricity. According to wind data in this study, it is found that the wind direction changes all the time and it will change a lot when the season changes. Finding a position to start waiting for the wind of the wind turbine by the presented method in this study results in change of the wind waiting direction based on the standard deviation value and erred value control by using the rejection of data method.

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