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Analysis of Wind Data Collected from 15 Stations in Thailand

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ABSTRACT

The aim of this research is to study the wind speed, wind direction and the temperature of 15 stations of Thailand at 5 levels from 16 November 2019 - 13 February 2020. WAsP application is used in this research to calculate the two parameters Weibull distribution namely K shape and C scale. Furthermore, maximum and minimum wind speed is recorded. Data from Nakhon Si Thammarat shows the maximum mean wind speed 5.02 m/s. and Nan shows the minimum mean wind speed 0.8 m/s. Additionally, the prominent wind direction of every station is observed as well. Main wind direction for Nakhon Si Thammarat is from (Southwest). These results facilitate for the further research on wind characteristic feasible for small wind farm by increasing the timeline of data recorded.

1. Introduction

In the recent few decades, as we are defied with environmental issues, for example, the consumption of electricity and petroleum products extracted from fossil fuel which is causing global warming and damage to the nature due to this critical reason the advancement of new and environmentally friendly power sources should be empowered to reduce the negative environmental effects caused [1][2]. There are several kinds of new and environmentally friendly energy sources. Furthermore, among them, the wind power is an important future power source. As it utilizes wind to instigate the rotational movements of blades, producing kinetic energy, which is thusly changed over into electric energy [3]. The technology to produce energy by using wind is the most cutting-edge innovation among new and sustainable power sources, and numerous nations all throughout the planet have put forth incredible attempts to refine wind power generation technologies and increased the efficiency [4]. Wind turbines are used to produce energy by extracting kinetic energy, classically by rotating shaft [5]. Thus, wind turbine power is among the most potential methods to generate power as the wind continuously around us [6].

Among some European nations, 15–30% of the overall power generation has been substituted by wind energy [7][8]. Along with the fast development of the wind power market around the globe,

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small size wind power generators have accomplished a considerable degree of advancement, and there are roughly 250 small size wind power turbine producers in 26 nations all throughout the planet. The advancement of small size wind power began in the mid-1980s, and the small size wind power plant expected to increase rapidly in the coming years [9].

Thus, small scale wind energy framework can provide a sufficient contribution to our energy demands. The classification of the small size wind turbine can be characterized into "micro", "small", "medium" or "mid-sized". Yet, globally there is no standard definition for small size wind turbine. Nonetheless, usually the limit of up to 1 kW-class is tagged as "micro"; the limit of 1–30 kW-class is tagged "small wind turbine"; the limit of 30–300 kW is classified as "medium" or "mid-sized" [9].

The small-scale wind power turns out to be so much firmly identified with the regular day to day existence of individuals, as they are utilized for the generation of electricity for individual houses in the limited areas where wind resources are not sufficient enough build up the wind power. Additionally, as they are appropriate for small-scale wind zones and do not require huge infrastructure for transmission lines and facilities, they are reasonable for smart grid as a decentralized power supply framework. Furthermore, small-size wind turbine produces less noise and vibration and can be installed in a limited area.

Additionally, the utilization of hybrid power generation system by combing different environmentally friendly energy production can increase the generation efficiency dramatically. However, one impediment is that the expense of energy is moderately higher than a large-scale wind power [10]. The improvement of wind power requires plentiful wind resource to produce power. Nonetheless, wind power generation in tropical regions including South Pacific is not as efficient as other parts of the world, due to the insufficient wind speed.

Furthermore, some developing nations have inadequate infrastructure for electricity generation and lack in innovation, technology and economy, these countries experience issues setting up the electricity generation system and fulfilling the need and supply of energy. Considering this, a small-size wind power framework should be presented with regards to the wind resource conditions and the climate of the area, where a large-scale wind power framework inappropriate. As of late, numerous analysts have researched for assessment of small wind power around the globe. In different works, practicality assessment of wind energy potential in the northwest shore of Senegal has been studied. The yearly mean wind speed of Senegal shifts from 4.16 m/s to 4.49 m/s. Additionally, the yearly energy production differs from 635 kWh/year to 1470 kWh/year for the small-size wind turbine [4]. Likewise, in different works, the yearly energy production of Hofa small-sized wind farm situated in the north of Jordan is analysed. In Hofa small-sized wind farm, the yearly energy production changes from 2250 MWh/year to 2550 MWh/year [11]. Through these previous works, we can ascertain with precision the possibilities of wind energy and plan to develop wind farm with the most favourable way. Consequently, this paper assesses the wind energy potential by processing and analysing the meteorological data in Thailand, collected from 15 Stations located in 6 different regions of Thailand.

Thailand has been divided into six regions, depending on topography and geography by the National Research Council. To be specific these regions are the Northern part, the Northeast part, the Central part, the Eastern part, the Western and the Southern part of Thailand. Every region of Thailand contrast from the each other in the sense of population, natural resources, and level of social and financial. Northern Part of Thailand is a mountainous region. Rivers unite in the lowland of the lower northern region such the Nan River, Ping River Wang River and Yom River. Due to this reason the area is suitable for several kinds of agriculture such as wet-rice farming. Widely area is covered with the forest but has declined dramatically from 1961 by mid 1980s ranging from 56% of the country to less than 30%. The North-eastern part of Thailand has poor soils condition and it is not

quite suitable for the agriculture. Nevertheless, this region is famous for its sticky rice cultivation, which requires, swamp land. Moreover, silk is a significant cottage industry as well. Contrasting to other regions of Thailand, North-eastern Thailand is relatively dry and floods during the short monsoon season. Furthermore, the central Thailand which is also known as "the rice bowl of Asia", has a complex irrigation framework made for the wet-rice cultivation in the area. The unchanging landscape helps the inland water and road transportation. Additionally, Eastern Thailand has relatively smaller mountain ranges with small basins of small rivers which fall into the Gulf of Thailand. Agriculture and Seafood industry plays a vital role in the economy of this region. Western part of Thailand is bordered with Myanmar and has a long mountainous range, this region is similar to the Northern region of Thailand buy with less forest area. There are some major dams of Thailand and mining is one of the main industries in this region. Finally, the Southern part of Thailand is located in the narrow peninsula with peculiar climate and terrain. Tourism, palm oil and rubber plantation are the main sources of the economy. This region has mountainous terrain but there is no big river in the area [12].

The climate of Thailand has influence by monsoon winds with seasonal characteristics (the southwest and upper east monsoon) [13]. The plentiful rain around the country is caused by the warm and moist air starting from May until October, from the Indian ocean to Thailand generally known as the southwest monsoon and from October till February the cold and dry wind blows from China, called as the northeast monsoon. The northeast monsoon causes mild weather and plentiful rainfall on the eastern coast of Southern Thailand. Overall, the climate in Thailand is tropical wet and dry or in savanna climate [14].

The mean yearly rainfall in the most of areas of Thailand in about 1,200 to 1,600mm. Nevertheless, there are certain areas located in southern and eastern parts of Thailand which receive more than 4,500mm rainfall per year due to their windward sides of mountain location [15]. Figure 1 shows the map portraying the climate classification of Thailand [16].

Across Thailand, few studies have been conducted to analyse the wind potential in the past by applying different models. However, this paper aims to study the wind data to figure out regions with maximum and minimum wind speed as well as the prevailing wind direction for every stations.

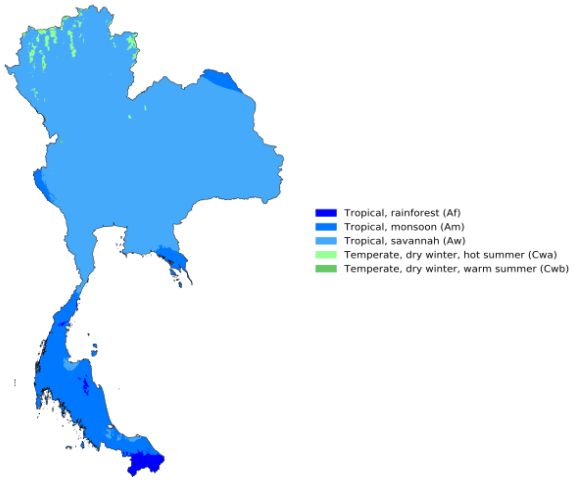

Fig. 1. The map portraying the climate classification of Thailand

2. Methodology

2.1 Analysis of Meteorological Data

The procedure to study wind resources and to analyse the data for the wing energy potential assessment is characterized as precision survey. This survey is used to assess the possibility of potential wind and the optimal framework for the turbine capacity.

Moreover, Wind Atlas Analysis and Application Program (WAsP) is utilized to process the wind data. This software was developed in 1987 at the wind energy and atmospheric physics department of Riso National Laboratory in Demark. It is used to analyse the wind data, generation of the wind atlas, forecasting of wind climate, wind turbines siting and wind farm power generation precautions, thus WAsP has gained credibility of being a vital tool in wind energy industry [17].

2.2 Wind Data Collection

As Thailand is divided into six regions, the wind data has been collected from the 15 different stations spread across the six regions by installing wind speed and direction sensor, atmospheric temperature sensor, data logger for the weather station and solar power system, collectively known as wind energy monitoring system. The data was collected at height of 10m, 15m, 20m, 25m and 30m from the ground level for three months (16 November 2019 - 13 February 2020). Thai meteorological department facilitated the whole process of installation and observation of the wind data. Table 1 shows the technical specification of the equipment.

Table 1
The technical specification of the equipment

Item	Technical Specification	
	Wind speed	Wind direction
Rang	0-60m/s	0-360˚
Resolution	0.2m/s	1˚
Accuracy	±2%	≤±3˚
Acquisition Cycle	3s	
Supply	12-24VDC	
Output Signal	RS485,4-20ms	
Operating Temperature	-40˚C-+70˚C	
Ingress Protection	IP65	
Main material	Housing: AIMgSi. Gray anodized	
Storage	10-60˚C@20%-90%RH	
Dimensions	265 (h) x 360 (Ø) mm	
Weight(unpacked)	380g	

As mentioned earlier the meteorological data was collected from 15 stations at 5 different levels. The data collection involved assortment of the fundamental variables required for the wind assessment, namely, wind speed and direction additionally air temperature information at 10-minute gap for 3 months. Table 2 shows the name of the province where the station is located including the geographical position and zone.

Table 2
The name of the province where the station is located including the geographical position and zone

Province	Easting	Northing	Lat-long	Zone
1. Narathiwat	829308.68 m E	666967.99 m N	6°01'33.3"N 101°58'28.0"E	47 N
2. Songkhla	655280.79 m E	768778.48 m N	6°57'10.6"N 100°24'20.2"E	47 N
3. NakhonSiThammarat	605545.13 m E	932493.62 m N	8°26'05.2"N 99°57'31.6"E	47 P
4. Surat Thani	533804.83 m E	1007517.54 m N	9°06'51.9"N 99°18'27.6"E	47 P
5. Prachuap Khiri Khan	586483.78 m E	1306008.74 m N	11°48'47.1"N 99°47'38.0"E	47 P
6. Chanthaburi	186140.07 m E	1395149.17 m N	12°36'16.9"N 102°06'40.8"E	48 P
7. Phetchaburi	602281.19 m E	1448988.39 m N	13°06'19.6"N 99°56'36.8"E	47 P
8. Ubon Ratchathani	485850.48 m E	1684294.49 m N	15°14'05.1"N 104°52'05.7"E	48 P
9. Khon Kaen	267900.98 m E	1815834.19 m N	16°24'45.8"N 102°49'35.8"E	48 Q
10.Lop Buri	679436.34 m E	1636417.14 m N	14°47'45.2"N 100°40'02.2"E	47 P
11. Nong Khai	261042.66 m E	1978465.65 m N	17°52'51.6"N 102°44'41.1"E	48 Q
12. Pattani	747465.80 m E	760982.53 m N	6°52'45.4"N 101°14'21.8"E	47 N
13. Kanchanaburi	559662.12 m E	1547769.13 m N	13°59'59.1"N 99°33'08.9"E	47 P
14. Nan	687057.45 m E	2080610.98 m N	18°48'31.8"N 100°46'30.1"E	47 Q
15. Chiang Mai	497991.68 m E	2076935.33 m N	18°47'02.6"N 98°58'51.4"E	47 Q

This research calculates the three months climatological characters by analysing the data collected by 15 stations. Among these stations, Lopburi showed the highest temperature which is 30.9 ^{o}C and Nan showed the least temperature 15.10 ^{o}C. In contracts, the humidity ranged from 37 to 99. Humidity was high in Nakhon Si Thammarat and Lopburi showed the least humid area. Moreover, when the temperature increases the humidity decreased because the quantity of saturated water vapor increased. Overall, Thailand is a humid country with tropical temperature.

3. Results and Discussion

3.1 Wind Speed Distribution

The three months wind speed distribution of the observed gust and wind speed at 5 different level are recorded and analysed. Frequency distribution is used to study the fluctuations of the actual speed and direction of wind recorded [18]. First of all, the wind data is characterized in Ms. Excel, then the data in entered in WAsP software to apply distribution function to the wind speed data and generate wind rose and Weibull distribution.

The Weibull distribution is the most appropriate function to elaborate the wind speed nature among other distribution functions. It is based on two parameters i.e., shape and scale parameter. Shape parameter is represented by k and scale parameter is represented by c.

Weibull distribution function is expressed as follows [19].

$$P_{(v)} = \frac{k}{v}\left(\frac{v}{c}\right)^{k-1} exp\left\{-\left(\frac{v}{c}\right)^{k}\right\} \quad (1)$$

The $P_{(v)}$ represents the frequency wind speed, v. The scale factor c (m/s) represents the mean wind speed and the dimensionless shape factor k indicates the shape and width of the distribution. Hence, the parameters c and k determine the Weibull distribution. The cumulative Weibull distribution, $P_{(v)}$, which gives the probability of the wind speed greater than the value, v, is expressed as:

$$P_{(v)} = exp\left\{-\left(\frac{v}{c}\right)^{k}\right\} \quad (2)$$

Table 3 shows the shape parameter K 4.63 and the shape parameter c 5.5 and mean speed 5.02 m/s of Nakhon Si Thammarat. This region shows the highest mean speed among the other selected provinces of Thailand. On the other hand, table3 shows the shape parameter K 0.97 and the shape parameter c 0.8 and mean wind speed 0.8 m/s of Nan. Nan shows the lowest mean speed as compared to other provinces.

Table 3
The shape parameter K, shape parameter C and mean speed

No	Wind statistics	"Hub height (m)"								
		10 m.			15 m.			20 m.		
		k	c	U	k	c	U	k	c	U
1	Narathiwat	1.97	3.0	2.68	2.23	3.3	2.91	4.21	1.4	1.29
2	Songkhla	2.15	2.4	2.14	2.67	2.8	2.53	3.52	6.0	5.41
3	Nakhon Si Thammarat	3.40	4.8	4.27	3.81	4.9	4.39	3.75	4.8	4.33
4	Surat Thani	2.72	3.1	2.73	3.62	3.4	3.05	3.75	3.5	3.13
5	Prachuap Khiri Khan	1.48	2.0	1.77	1.63	2.3	2.03	1.98	2.5	2.26
6	Chanthaburi	1.37	2.4	2.20	2.00	4.0	3.57	1.89	3.00	2.63
7	Phetchaburi	1.05	1.6	1.56	2.3	1.20	2.15	1.69	2.3	2.06
8	Ubon Ratchathani	1.73	3.7	3.27	1.57	3.4	3.04	1.76	4.0	3.35
9	Khon Kaen	1.50	1.3	1.15	2.42	2.1	1.82	4.51	3.6	2.46
10	Lop Buri	1.52	2.1	1.89	1.64	2.3	2.03	2.00	4.4	3.88
11	Nong Khai	1.59	2.9	2.62	1.62	3.0	2.72	1.64	3.1	2.79
12	Pattani	1.24	2.3	2.19	1.23	2.4	2.20	1.52	2.8	2.48
13	Kanchanaburi	1.12	1.9	1.87	1.24	2.2	2.08	1.25	2.2	2.08
14	Nan	0.97	0.8	0.80	0.95	0.8	0.85	1.17	0.9	0.87
15	Chiang Mai	0.92	1.3	1.39	1.26	1.0	0.89	1.28	1.1	0.98
No	Wind statistics	"Hub height (m)"								
		25 m.			30 m.					
		k	c	U	k	c	U			
1	Narathiwat	3.27	2.0	1.83	4.43	3.6	3.24			
2	Songkhla	3.57	3.4	3.11	4.18	3.7	3.41			
3	Nakhon Si Thammarat	4.02	5.4	4.93	4.63	5.5	5.02			
4	Surat Thani	3.75	3.5	3.32	2.97	3.7	3.31			
5	Prachuap Khiri Khan	2.31	3.0	2.62	2.34	3.1	2.71			
6	Chanthaburi	2.09	4.0	3.50	2.72	5.5	4.87			
7	Phetchaburi	1.77	2.8	2.53	1.91	2.2	1.96			
8	Ubon Ratchathani	1.74	3.9	3.45	1.88	4.1	3.68			
9	Khon Kaen	4.47	3.0	2.50	4.32	3.1	2.81			
10	Lop Buri	1.79	2.5	2.24	1.85	2.8	2.47			
11	Nong Khai	1.59	3.6	3.27	2.24	4.0	3.52			
12	Pattani	1.83	3.3	2.95	2.02	3.6	3.20			
13	Kanchanaburi	1.25	2.2	2.08	1.24	2.3	2.11			
14	Nan	1.18	1.5	1.45	1.20	1.6	1.48			
15	Chiang Mai	2.52	1.7	1.52	1.98	1.9	1.68			

Figure 2 shows the histogram of Nakhon Si Thammarat. As shown in the histogram, this province has the highest mean speed as compared to other provinces. "U" represents the wind mean speed, which is 5.02 m/s.

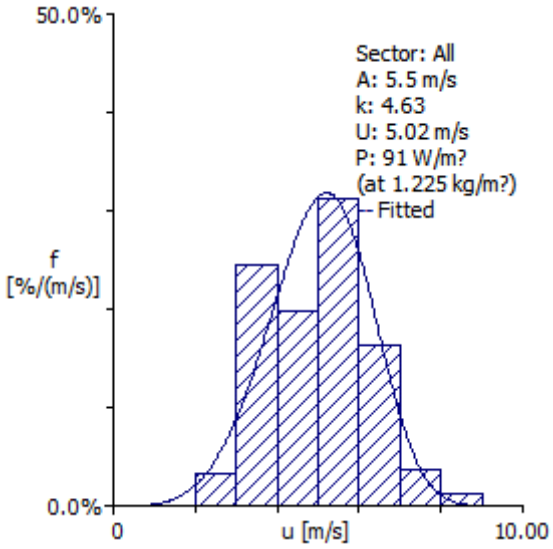

Fig. 2. Histogram of Nakhon Si Thammarat

Figure 3 portrays the histogram of Nan province. According to the data this province has the lowest mean speed as compared to other provinces. The mean wind speed of Nan is 0.80 m/s.

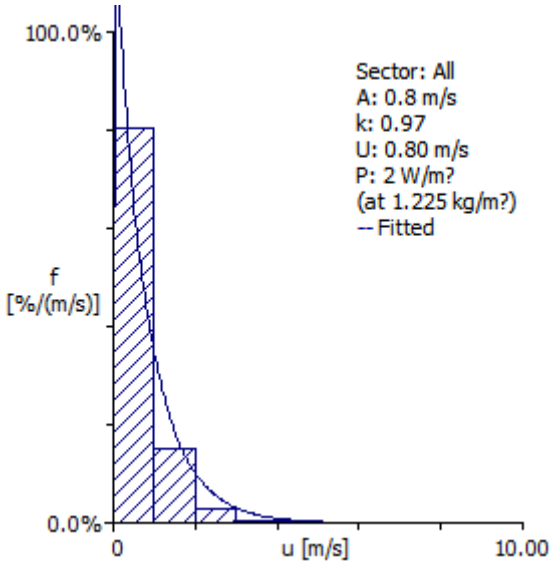

Fig. 3. Histogram of Nan

3.2 Wind Direction

Another vital factor to be considered together with the wind speed is the wind direction. According to Figure 4. the main direction of the Nakhon Si Thammarat is from the Southwest. Wind rose shows the specific direction of the wind is 25%. Considering other regions of Thailand, the main direction in the Northern part of Thailand is northeast, the Central part southwest, the Eastern part is northeast, the western part is southeast and finally the Southern part wind direction is from southeast.

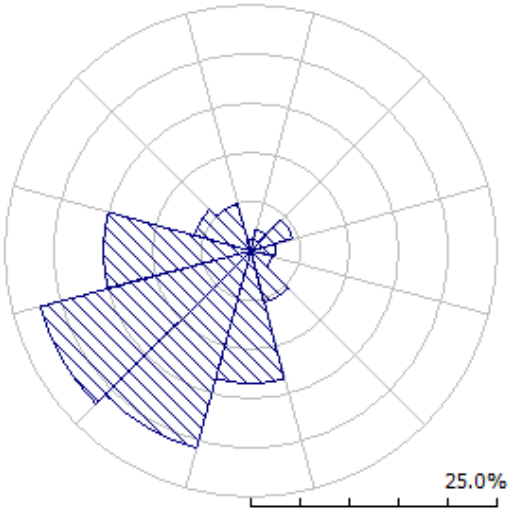

Fig. 4. Wind Rose of Nakhon Si Thammarat

4. Conclusions

This paper performed a precision study method on wind data of 15 stations in Thailand by assistance of Thai metrological station while collecting the data for three months. During this span of time the result produced shows the highest temperature in Thailand which is 30.9 ^{o}C and, on the hand, Nan showed the lowest temperature 15.10 ^{o}C.

Moreover, the highest mean speed was recorded in Nakhon Si Thammarat which is 5.02 m/s. Additionally, lowest mean speed was recorded in Nan which is 0.8 m/s. Furthermore, the main wind direction for the Nakhon Si Thammarat station was from Southwest direction.

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