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Wind Speed Measurements and Comparisons in Cakung Jakarta

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ABSTRACT

Standard procedure to find the highest wind speed in an office area is defined, exercised and verified. Different tools are used in the procedure to find and measure wind speed at different locations starting from already available wind speed data at the Global Wind Atlas, then verified with a handheld anemometer and with a weather station. Wind data collections using handheld anemometer and weather station were done at 2-meter elevation and compared with the lowest elevation data available in the Global Wind Atlas at 10-meter height.

This procedure is applied in West Cakung Office area which is in an industrial complex in East of Jakarta. This project can contribute to other companies in the industrial complex to develop wind energy projects.

We found that the wind speed average from the Global Wind Atlas at 10-meter elevation, 1.43 m/s, higher than any measurements done at 2-meter elevation in several spots using handheld anemometer and weather station, 0.5 - 1.4 m/s. The measurement results using handheld anemometer is consistent with using weather station. The highest wind speed at 2-meter elevation occurs at a site located between two large buildings which create tunneling effect and amplify the wind speed. This site has higher wind speed even compared to the site 2-meter on the roof of buildings due to obstacles from walls and other structures on the roof.

Wind speed measurements using weather station was also done at higher elevation with the support of air balloon. The height of the air balloon is around 10 – 15 meter above the ground. We found that the wind speed average at this level is 1.6 m/s, which is slightly higher than the data from the Global Wind Atlas due to slightly higher elevation and maybe due to air acceleration around the balloon which has 1.5-meter diameter.

Although the wind speed average is consistent for all three sources: Global Wind Atlas, handheld anemometer, weather station, but the daily wind speed hourly index is not consistent. Wind speed data from the Global Wind Atlas shows that the peak of wind speed occurs in the morning time, while the data from handheld anemometer and weather station shows that the peak of wind speed occurs in the afternoon time. More investigations will be done to explain this inconsistency in the future work.

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CCS CONCEPTS

• **Hardware**; • **Power and energy**; • **Energy generation and storage**; • **Renewable energy**;

KEYWORDS

wind speed, measurement, comparison, cakung, Global Wind Atlas, anemometer, weather station

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1 INTRODUCTION

Electrical energy can be regarded as the primary need of every human being in every sector starting from the industrial sector, transportation, households, power plants, public facilities, and so on. World Energy Outlook [1] shows that global demand for electrical energy is growing by 2.1% per year until 2040. This increase is expected to be very strong in developing countries, one of which is Indonesia. Based on data published by Perusahaan Listrik Negara (PLN) in 2021 [2], the main source of electrical energy in Indonesia is dominated by coal-fired steam power plants (PLTU) as much as 62.59% of the total electrical energy produced. Considering that coal is a non-renewable energy, it is necessary to prepare for the transition to renewable energy.

The Ministry of Energy and Mineral Resources (ESDM) has noted that the achievement of the New Renewable Energy (NRE) mix in 2021 has only been realized at 11.5% [3]. The Government of Indonesia has targeted the NRE mix of 23% in 2025 and 31% in 2050. As a form of the government of Indonesia's seriousness in developing NRE, the government formed a regulation in "Peraturan Pemerintah Nomor 79 Tentang Kebijakan Energi Nasional pada Pasal 22 Ayat 1" states that the government and local governments provide fiscal and non-fiscal incentives to encourage diversification

of energy sources and the development of renewable energy. All support for NRE development is based on the achievement of the Sustainable Development Goals (SDGs), especially point number seven on clean and sustainable energy. Therefore, this is a challenge for the government of Indonesia to encourage the development of each NRE that is effective and efficient with supporting factors in Indonesia so it can achieve the specified target.

Wind turbines or Wind Power Plants (PLTB) are one of the implementations of NRE to produce electrical energy with the principle of changing the kinetic energy of the wind then mechanical energy and finally into electrical energy through the rotation of the generator. The advantages possessed by PLTB include relatively low operational costs and do not require large areas of land such as Solar Power Plants (PLTS). Until 2021, only 131 MW of PLTB have been installed, or 0.2% of the energy mix in Indonesia [4]. Meanwhile, the target capacity in 2025 is 255 MW or 7.7% of the energy mix in Indonesia. This is because Indonesia is located on the equator where the wind speed often turns and is not constant. Therefore, Indonesia has not worked optimally on the development of PLTB as a massive producer of electrical energy. The development of PLTB in Indonesia is still challenging and different design of Vertical Axis Wind Turbine for the application in Indonesia has been studied in Refs. [5, 6].

Accurate survey of wind energy potential locations throughout Indonesia is very necessary as the first step in identification, selection of the appropriate type of turbine, and selection of PLTB installation locations. It can provide information about wind characteristics in various regions such as average, maximum, and minimum wind speed. Measurement of wind speed has been done, namely tracing the value of wind speed in the building area in Bandar Lampung and the average wind speed obtained is around 1.56 m/s [7]. Similarly, study of available wind speed in the south coastal area of Gorontalo Regency has been done in [8] and the highest average wind speed was around 4.2 m/s. Wind farm design for Oelbubuk in East Nusa Tenggara has been studied in [9] and they found yearly average wind speed of 7.3 m/s at 50-meter elevation. Measurements of wind speed in different locations were also done in Refs. [10][11][12][13][14][15].

In this EBT research projects, we are tracking wind characteristics data in Cakung office area to find out the most optimum locations. This aims to obtain the best method for wind speed data collection, especially about the characteristics of the wind source as one of the main factors determines before installing a wind turbine as an electricity generator. Several methods will be considered and compared, such as Wind Speed data collection from the Global Wind Atlas website, wind speed measurement using a handheld anemometer, wind speed measurement using a weather station, and higher altitude measurement supported by air balloon.

2 RESEARCH METHODOLOGY

2.1 Global Wind Atlas

The easiest data collection of wind speed is from the Global Wind Atlas website [16]. This website can provide maps of wind speed distribution in almost everywhere on the Earth. In example, Global Wind Atlas can show wind speed distribution in the Java island at the elevation of 10 meters above the ground as shown in Fig. 1.

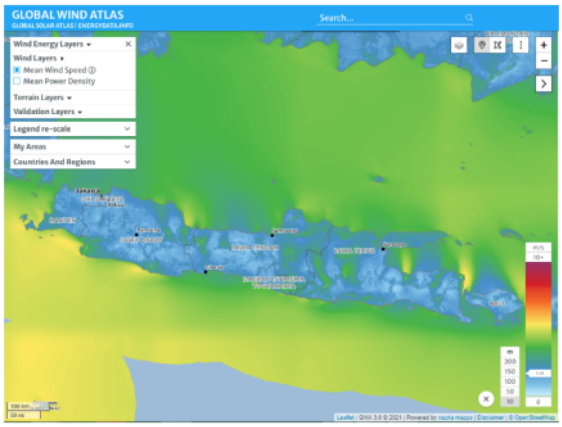

Figure 1: Wind Speed Distribution at The Elevation Of 10-Meter Above the Ground in Java Island from The Global Wind Atlas

Figure 2: Simple Handheld Anemometer.

Notice that the wind speed in most of the java area is quite low, around 1.5 m/s with some local areas with higher wind speed.

Wind data at different elevation are available in the Global Wind Atlas, at 10, 50, 100, 150 and 200 meter above the ground. This is suitable for different wind turbine tower heights. The lowest elevation is 10 meter which is higher than most obstacles on the ground, such as houses, fences and trees.

2.2 Handheld Anemometer

To support the initial data, wind speed data was collected in a conventional way, namely using a handheld anemometer at several locations. Data retrieval is carried out with different time variations during working hours, from 8:00 to 16:00 o'clock with a span of one hour. The handheld anemometer used in this project is shown in Fig. 2. This tool can measure not only wind speed, but also air temperature. To measure the wind speed properly, the blades need to be directed along with the wind direction. To do that, simply by rotating around the tool until the highest wind speed measurement is found.

Figure 3: Weather Station Consists of Outdoor Sensors and Indoor Monitor. Outdoor Sensors Are Supported By 2-Meter Pole with Cemented Bucket.

Figure 4: Display from ecowitt.net Website to Show Wind Data from The Weather Station.

2.3 Weather Station

Wind speed data retrieval is also done using a weather station at several locations in the Cakung office area at the elevation of 2-meter from the ground. Real-time data will be visible on a monitor with integrated Wi-Fi and can be monitored on the website and application as well. Wind speed data retrieval is carried out for approximately one week at each location. The monitor must be connected to electrical power and also connected to Wi-Fi continuously for data sending everytime to be recorded on the website and application. The maximum distance between the monitor and the weather station is 100 meters. The weather station configuration is shown in Fig. 3

Data will be monitored through the website at ecowitt.net and available to be downloaded in the form of an Excel document. The front page displayed on the website is in the form of a graphic as shown in Fig. 4. Not only the wind speed recorded at the weather station but also wind gust. A wind gust is a sudden, brief increase in the speed of the wind followed by a lull, usually less than 20 seconds. However, wind gust is not a parameter that is used as a wind energy indicator but for a construction consideration parameter of a wind turbine.

Wind speed data collection is carried out for one to two weeks whose overall data is averaged based on the hour and day. The weather station outdoor sensors are mounted on 2-meter pole that

Figure 5: Eight Locations of The Weather Station in Cakung Office Area for Wind Speed Measurements.

Figure 6: Air Balloon With 3 Anchoring Ropes for Position Stability. Weather Station Outdoor Sensors Are Hung to The Air Balloon.

is given a dry cement in container with a mass of approximately 70 kg so the support is sturdy and does not fall easily but still moveable. There are 8 locations of weather station to retrieve wind data around the Cakung office area as shown in Fig. 5

2.4 Air Balloon

It is necessary to retrieve wind speed data at a higher altitude to avoid obstacles such as buildings and trees. Wind speed data retrieval for this elevation is carried out using air balloon for a week in the altitude about 10 to 15 meters in the Cakung office area as shown in Fig. 6. The air balloon has 1.5-meter diameter and it is made of PVC material. The PVC air balloon is durable in the air and quite thick, 0.17 mm so the gas inside the air balloon does not come out easily. The gas used is hydrogen because it has good lifting power, and also commonly used for outdoors. Although hydrogen is flammable, but as long as there is no contact with fire, it should be safe.

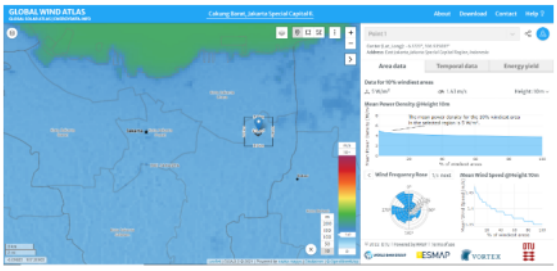

Figure 7: Wind Speed Distribution at The Elevation Of 10-Meter Above the Ground in West Cakung Area.

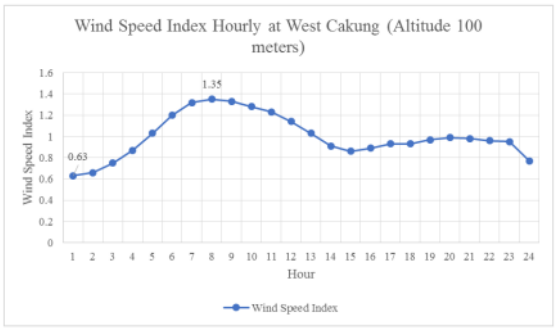

Figure 8: Wind Speed Index as A Function of Time at The Elevation Of 100-Meter Above the Ground in West Cakung Area.

3 RESULT AND ANALYSIS

3.1 Global Wind Atlas

Wind speed data in the Cakung office area, which is part of West Cakung region at 10-meter elevation from the Global Wind Atlas is shown in Fig. 7. The average wind speed was recorded at around 1.43 m/s.

The wind speed will not always be the same at each hour. According to the Global Wind Atlas, the West Cakung area recorded the highest wind speed index at 8:00 o'clock with a value of 1.35 and the lowest wind speed index at 1:00 o'clock with a value of 0.63 as shown in Fig. 8. This index is a relative value to the wind speed average. Based on this graph, relatively higher wind speed would occur in the morning time, regular wind speed from afternoon time till just before the mid-night and low wind speed from mid-night until dawn.

The Global Wind Atlas also provides information on wind speed monthly variation for the whole year. This information is usually related to the seasons in the area. Wind Speed Index Monthly is shown in Fig. 9. Based on the graph, from the month of April until November, wind speed is less than average. Peak of wind speed occurs in the month of December and January.

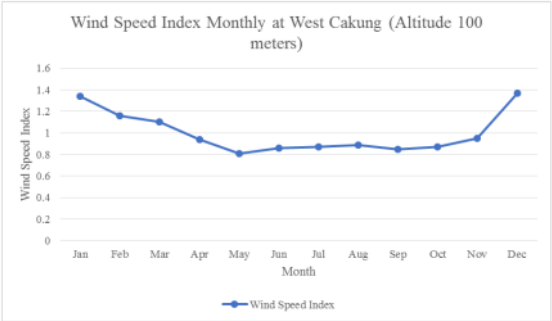

Figure 9: Wind Speed Index Monthly at The Elevation Of 100-Meter Above the Ground in West Cakung Area.

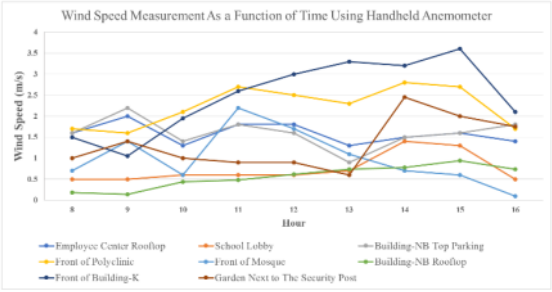

Figure 10: Wind Speed Measurements At 8 Locations as A Function of Time Using Handheld Anemometer.

3.2 Handheld Anemometer

The locations of wind speed data retrieval using the handheld anemometer are the same locations as the weather station. The results of wind speed data retrieval using the handheld anemometer are presented in Fig. 10. The graph shows that the highest wind speed curves are for the locations in front of Building-K and in front of Polyclinic. While in School lobby and Building-NB rooftop are the lowest curves in the graph because for those two locations, there are obstruction objects from several directions, especially blocked by buildings.

Based on the graph in Fig. 10, the peak of wind speed occurs in the afternoon time while the data from Global Wind Atlas in Fig. 8 shows that the peak of wind speed occurs in the morning. This means that the trend of wind speed hourly from the Global Wind Atlas does not match the data from the handheld anemometer.

3.3 Weather Station

The wind speed measurement results from the weather station are presented in Table 1 and in Fig. 11 and the results are similar to the data taken by the handheld anemometer.

The highest wind speed measurements are taken in front of Polyclinic and in front of Building-K, which have wind speed averages

Table 1: Wind Speed Average at 8 Locations Using Weather Station.

No	Location	Wind Speed Average (m/s)
1	Employee Center Rooftop	1.2
2	School Lobby	0.5
3	Building-NB Top Parking	1.2
4	Front of Polyclinic	1.4
5	Front of Mosque	0.6
6	Building-NB Rooftop	0.5
7	Front of Building-K	1.3
8	Garden Next to the Security Post	1.1

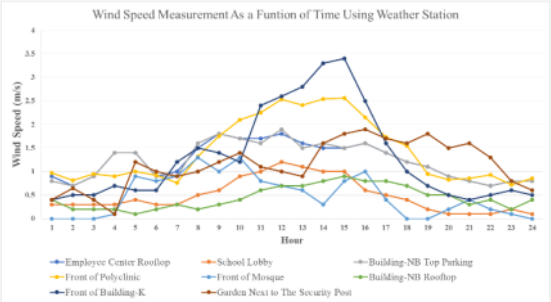

Figure 11: Wind Speed Measurements at 8 Locations as A Function of Time Using Weather Station.

Figure 12: Tunneling Effect Between Two Large Buildings Resulting Higher Wind Speed Measurements.

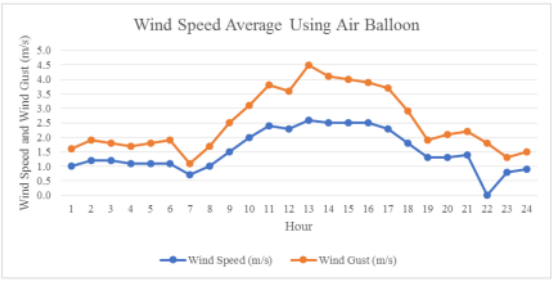

Figure 13: Wind Speed Measurements as A Function of Time Using Weather Station Hung To the Air Balloon.

of 1.4 and 1.3 m/s. While the lowest are taken in School lobby and Building-NB rooftop with wind speed average for both of 0.5 m/s.

The wind speed average from weather station measurements at 8 locations are similar to the data from the handheld anemometer. The weather station measurement data in Fig. 11 is quite comparable to the handheld anemometer measurement data in Fig. 10, that the peak of wind speed occurs in the afternoon time. However, both data are inconsistent with the wind speed index hourly from the Global Wind Atlas in Fig. 8

Comparing the results in Table 1 to the wind speed average from the Global Wind Atlas, 1.43 m/s, the averages at 8 different locations are less than the one from the Global Wind Atlas. This is to be expected because all data in the table are collected in elevation of 2-meter, which is less than the Global Wind Atlas data at elevation of 10-meter. However, we learned that in some conditions, wind speed average is higher at different locations than areas with a lot of blockages. As shown in Fig. 12, the site in front of Polyclinic is between two large buildings creating tunneling effect that can accumulate wind energy resulting higher wind speed average.

3.4 Air Balloon

Wind speed at altitude of 10 to 15 meters has a slightly higher average value, although it is not very significant. The wind speed measurement using air balloon as a function of time is shown in Fig. 13. The average value of wind speed (blue curve in Fig. 13) obtained in one week is 1.6 m/s. The value of the wind speed average obtained is still close to the wind speed average value recorded on the Global Wind Atlas, which is 1.43 m/s.

When this data compared to the wind speed index hourly in West Cakung recorded in the Global Wind Atlas, the profile value is inconsistent. This data is more consistent with the measurement data from the handheld anemometer and the weather station at 2-meter elevation.

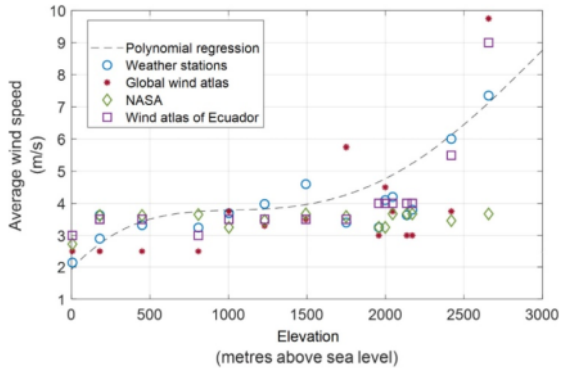

Figure 14: Average Wind Speed and Terrain Elevation Obtained from Weather Stations, Along with Other Data Sources for The Same Geographic Locations: Global Wind Atlas, NASA, And Wind Atlas of Ecuador. Source: Ref. [17].

Higher value of wind speed with increasing altitude has been studied in [17]. The paper showed that the wind speed is mainly a function of terrain elevation. Correlation of wind speed curve along with other data sources such as Weather stations, Global Wind Atlas and NASA is shown in Fig. 14. For the elevation range of 10 to 200 of our interest, the wind speed average curve in Fig. 14 shows that wind speed average is continuously going higher as the elevation going higher.

This justifies that the wind speed measurement using air balloon should be higher than using 2-meter elevation of weather station and handheld anemometer. The second reason is because at the altitude of 10 - 15 meter, there are fewer obstructions compared to the height of 2 meters. These obstructions will block the wind and reduces the wind speed.

4 CONCLUSION

The wind speed average at 10-meter elevation from Global Wind Atlas in Cakung office area is comparable to the data from handheld anemometer and weather station supported by 2-meter pole and by 10-15-meter elevation air balloon.

The daily wind speed index hourly from the Global Wind Atlas is not consistent with the data from handheld anemometer and weather station. The peak of wind speed from the Global Wind Atlas occurs in the morning time, while from handheld anemometer and weather station, the peak occurs in the afternoon time.

The highest wind speed average at 2-meter elevation from handheld anemometer and weather station measurements occurs in the front of Polyclinic and in front of Building-K with the value of 1.4 and 1.3 m/s. There is a tunneling effect happened at these two locations due their position between two large buildings.

The lowest wind speed average at 2-meter elevation occurs at the spots with large obstacles, such as trees, walls, buildings.

The wind speed average measured using air balloon is larger than any measurements done at 2-meter elevation. This follows the theory that wind speed average is higher at higher elevation.

ACKNOWLEDGMENTS

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REFERENCES

[1] International Energy Agency. 2019. World Energy Outlook. www.iea.org/topics/world-energy-outlook
[2] PLN. 2021. Statistik PLN 2021. https://web.pln.co.id/stakeholder/laporan-statistik
[3] Kementerian ESDM. 2021. Handbook of Energy & Economic Statistics of Indonesia. www.esdm.go.id/en/publication/handbook-of-energy-economic-statistics-of-indonesia-heesi
[4] Balai Besar Survei dan Pengujian Ketenagalistrikan, Energi Baru, Terbarukan, dan Konservasi Energi. 2022. Potensi Energi Angin Indonesia 2020. Esdm.go.id. https://p3tkebt.esdm.go.id/pilot-plan-project/energi_angin/potensi-energi-angin-indonesia-2020.
[5] Dena Hendriana, Eka Budiarto and Arko Djajadi. 2020. Experimental Simple Vertical Axis Wind Turbine for Low Wind Speed. In Proceedings of International Conference on Engineering and Information Technology for Sustainable Industry (ICONETSI 2020), September 28-29, 2020.
[6] Dena Hendriana, Eka Budiarto, Alexander Clements, Arko Djajadi. 2018. Design comparison of wind turbines for low wind speed, Proceedings of the International Conference on Innovation, Entrepreneurship and Technology, 30-31 October 2018.
[7] Pramono, Y., Warsito, & Syafriadi. 2016. Monitoring Data Kecepatan dan Arah Angin Secara Real Time Melalui Web. Jurnal Teori dan Aplikasi Fisika Vol. 04, No. 02, Juli 2016.
[8] Arthur Gani Koto. 2020. Study availability of wind speed in the south coastal area of Gorontalo Regency, Indonesia. Jurnal Sains Informasi Geografi Vol. 3 No. 2 November 2020.
[9] Herliyani Suharta, Sahat Pakpahan, Soeripno Martosaputro. 2011. Wind Farm design for Oelbubuk in East Nusa Tenggara, Indonesia. Journal of Informatics and Telecommunication Engineering JITE Vol. 1 No. 12, Februari 2011
[10] Firsta Zukhrufiana Setiawati, Rudi Kurnianto, Bomo Wibowo Sanjaya, Rudy Gianto, Seno Darmawan Panjaitan, Ananggirieza Nugraha. 2020. Performance of Wind Power Plant in West Kalimantan, Indonesia. Jurnal Edukasi dan Penelitian Informatika JEPIN Vol. 6 No. 3, Desember 2020.
[11] U.Z. Adlina, A. Ihwan, and Apriansyah. 2018. Potensi Energi Listrik Tenaga Angin di Kota Pontianak. Vol. VI (01), Prisma Fisika, 2018.
[12] K. E. Bawan. 2007. Kajian Potensi Energi Angin Kabupaten Kaimana Provinsi Papua Barat. Vol. 6 (2), Natural, 2007.
[13] A. Sam and D. Patabang. 2005. Studi Potensi Energi Angin di Kota Palu untuk Membangkitkan Energi Listrik. Vol. 3 (1), Jurnal SMARTek, 2005.
[14] Ryski. 2013. Kajian Kelayakan Potensi Energi Angin Pada Kawasan Universitas Tanjungpura Pontianak Untuk Dimanfaatkan Menjadi Energi Listrik. Jurnal Teknik Elektro Untan, Vol. 1, No.1, 2013.
[15] R. U. Irene, Muh. Ishak Jumarang, and Apriansyah. 2018. Perhitungan Potensi Energi Angin di Kalimantan Barat. Prisma Fisika, Vol. VI, No. 01, 2018.
[16] Global Wind Atlas. 2022. https://globalwindatlas.info/
[17] J.C. Solano. T. Montaño. J. Maldonado-Correa. A. Ordóñez, M. Pesantez. 2021. Correlation between the wind speed and the elevation to evaluate the wind potential in the southern region of Ecuador. 6th International Conference on Advances on Clean Energy Research, ICACER 2021 April 15–17, 2021, Barcelona, Spain

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