THE ANALYSIS OF LAPSE RATE PROFILE IN THE SITE CANDIDATE OF NUCLEAR POWER PLANT (NPP) AT GOSONG BEACH, BENGKAYANG REGENCY– WEST KALIMANTAN

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Abstract *The lapse rate profile in the site candidate for the Nuclear Power Plant (NPP) at Gosong Beach Bengkayang, has been investigated to obtain a description of the lability of the atmosphere and upper air as part of a meteorological aspect safety study in the plan to develop a NPP site. The study of the lapse rate was carried out using air data on the reanalysis of the Global Data Assimilation System (GDAS) by extracting air temperature data at each altitude level so as to obtain a lapse rate of up to 25 km. Daily data was processed during 2021 and transformed in the monthly average profile data to describe the lapse rate profile in January – December 2021. Tropopause was identified with average altitude about 16.6 km and stratosphere at 20.5 km with a lapse rate about -0.21 ℃/100 m. The surface layer to 200 m have lapse rate from 0.7 ℃/100 m - 0.9 ℃/100 m at 00.00 Universal Time Coordinated (UTC) and 0.5 ℃/100 m -0.6 ℃/100 m at 12.00 UTC*

INTRODUCTION

The study regarding the determination and construction of a Nuclear Power Plant (NPP) is a fundamental thing that must be carried out in an initial study of the location NPP construction site. Electricity sales increased by 7.8% per year for the last 5 years to 197.3 Terawatt Hours (TWh) in 2014 with an increase in the number of customers (3 million per year). Although based on the State Electricity Company (PLN) release per 2022, there has been a significant increase since the 2020 pandemic, PLN's cumulative sales until November 2022 reached 250.4 TWh which year on year (YoY) grew by 6.61%. The sector that contributes the most to electricity consumption in 2022 is the household segment, amounting to 106.23 TWh (42.43%). Then followed by the industrial segment of 81.17 TWh (32.42%), the business segment of 43.99 TWh (17.57%), the social segment of 9.18 TWh (3.67%), and the public segment of 7. 82 TWh (3.13%). However, the application of a peak load reserve of around 35% compared to the power generation capacity, the national electricity system is still not fulfilled. As a result, the State Electricity Company (PLN) needed to lease another power plant to meet the electricity supply shortfall of around 3,600 MW (1). Through this plan, studies must be carried out from various aspects in determining the site location, one of the studies that must be carried out at each NPPs location is a meteorological study (2–5).

The evaluation for the meteorological aspect includes: monitoring and collection of meteorological data and information; meteorological hazard evaluation; and determining the value of the basic parameters for the design of the NPPs installation. One of the meteorological studies can include analysis of the upper air by using radio sonde balloon. The study will describe the profile of upper air so that various aspects related to wind direction such as aspects radioactive materials dispersion can be minimized (3–6). Meteorological observations consist of observations on the surface and observations in the atmosphere otherwise known as upper air observations. One of the most important parts in the study and analysis of the upper air is knowing how the lapse rate conditions in certain areas are in order to determine the atmospheric conditions at each specific altitude (7).

Atmospheric conditions are generally described with an air stability profile that will describe potential events that will and are occurring in the atmosphere. Atmospheric conditions at each altitude also influence the determination of physical changes and dynamics of the atmosphere. Atmospheric stability is seen as a way to show the possibility and tendency of vertical movement of air from an air mass in the atmosphere which can be characterized by the relationship between temperature and altitude (8). Lapse rate is a parameter of the atmospheric stability section that can explain the tendency of an air mass movement in the atmosphere where the lapse rate is defined as the rate of change of temperature with altitude in the atmosphere. Usually, the rate of change in temperature occurs in the troposphere and is measured in units of ℃/100 m (9,10).

There are three types of lapse rates: the first is the environmental lapse rate which describes the rate of change of air temperature between two altitudes in the vertical and horizontal directions ($\Upsilon = \partial T/\partial H$). The second is the dry adiabatic lapse rate where unsaturated air parcels cool at speeds around 1℃/100 m and finally the wet adiabatic lapse rate where saturated air parcels cool at an average speed of around 0.450-0.6 ℃/100 m. The lapse rate change rate curve is shown in Figure 1, the temperature change rate will decrease with altitude and the state of stability in the atmosphere is described based on the rate of change of temperature (11,12).

Research related to lapse rate profile, particularly in the tropics, has been carried out quite a lot by researchers. In the layer between the well-mixed convective troposphere there is a transition layer known as the Tropical Tropopause Layer (TTL) which is radiatively controlled by the stratosphere. Vertically TTL can extend from a strong convective outflow to an altitude of between 12-14 km and even up to 18 km when convective overshooting occurs (13). Several other researchers found the characteristics of the tropical troposphere where the air temperature decreases with respect to the height with a typical lapse rate of 6.5 ℃/km. The temperature structure in this layer is a consequence of the radiative and convective balance of energy transport from the surface to the atmosphere. Research related to lapse rate profile needs to be carried out regarding atmospheric lability which leads to cloud growth and rain (14,15).

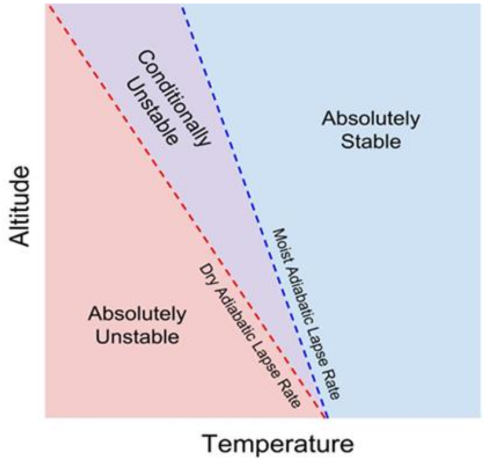

Figure 1. Atmospheric stability diagram (11).

It is hoped that the NPPs construction in Bengkayang Regency, West Kalimantan will increase electrification, which is currently around 93%. In terms of electric power, West Kalimantan does have excess energy, but most of the supply comes from a neighboring country (Sarawak, Malaysia) which is directly adjacent to this province. For the political and independence reason, West Kalimantan is known to be included in the Priority Industrial Areas outside Java, based on the National Industrial Master Plan (RIPIN) 2015-2035. The National Nuclear Energy Agency of Indonesia (BATAN) has started a NPP feasibility study starting in 2020 to ensure that a NPPs is safe to build in West Kalimantan as stipulated by the Nuclear Energy Regulatory Agency (BAPETEN). Broadly speaking, the roadmap for the National Research Program (PRN) for NPPs, the first five-year period (2019-2024) is phase I (pre-project stage). Until mid-2021, BATAN has conducted a comprehensive feasibility study and site study, including an economic feasibility study, as well as a technical study, to identify the most appropriate technology and design for NPPs for the conditions in West Kalimantan. Various aspects that have been studied include meteorology, demography, land use, water and sea, human-made events, volcanoes, geology, earthquakes, tsunamis, and others. Previous studies have focused on strategic location aspects to be used as potential NPPs sites, such as Gunung Muria

(Jepara Regency, Central Java), Kramatwatu (Banten), Bangka Island, West Nusa Tenggara, and East Kalimantan (16,17). The study of the lapse rate profile is one of the important reference studies in considering the candidate site of the NPP and construction also. Thus, this study aims to describe and analyse the lapse rate profile at the NPP site location at Gosong Beach, Bengkayang Regency.

EXPERIMENTAL SECTION

Materials

Equipment used Radiosonde Transmitter, balloon sonde, parachute, hydrogen gases, paper label, marker, paper and scales. In addition, secondary model data are used, including data reanalysis of the Global Data Assimilation System (GDAS). The Global Data Assimilation System (GDAS) is the system used by the National Center for Environmental Prediction (NCEP) Global Forecast System (GFS) model (18). GDAS adds the following types of observations to the 3-D grid model space: surface observations, overhead balloon data, wind profile data, aircraft reports, buoy observations, radar observations, and satellite observations (19,20).

GDAS data is available through NOAA's National Operational Model Archive and Distribution System (NOMADS) accessed through www.ready.noaa.gov/READYYamet.php. The reanalyzed aerial data has a spatial resolution of 1° x 1° with global coverage with up to 3-hour temporal resolution. The study period in this study covers January 2021 – December 2021 (daily data). The research location is depicted in Figure 2 with the location of Gosong Beach, Bengkayang Regency.

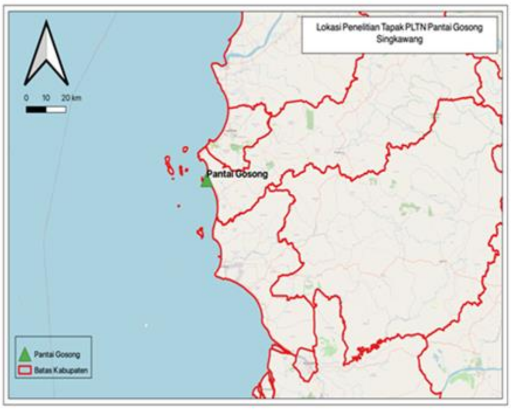

Figure 2. NPP site candidate in Gosong Beach, Bengkayang Regency, West Kalimantan (Latitude Coordinates : 0.71 ; Longitude : 108.881).

Instrumentation

The Instrument used includes: ground equipment that is the main set of tools needed to follow the trail radiosonde, receives the transmitter signal and converts the signal into temperature data, pressure, and humidity and process the data into observational data. Ground equipment consists: antenna system, Global Positioning System (GPS), computer data processing, baseline check, and power system.

Methods

This research was carried out by collecting air temperature data from the surface layer to 20 km height daily at 00.00 UTC and 12.00 UTC in the period January 1, 2020 to December 10, 2020. The data was collected and then tabulated in the form of tabulation of upper air with daily data 00.00 UTC and 12.00 UTC then processed to get the average for each month with the following formula:

$$\mu = \frac{1}{N}\sum\nolimits_{i=1}^{N} X_i$$

where: μ is the mean or average; N is amount of all data, and $\sum_{i=1}^{N} X_i$ is the amount all frequency from 1 to N.

The average data for each month is used to calculate the lapse rate by applying the initial interpolation at the height levels every 100 m with the formula:

$$Y = \frac{Y_2 - Y_1}{X_2 - X_1}(X - X_1) + Y_1$$

The results of the interpolation process also need to be controlled on the data by applying the removal of outliers by using the following formula:

$$Q_3 + (1.5 \times IQR) < outlier \leq Q_3 + (3 \times IQR)$$

Or

$$Q_1 - (1.5 \times IQR) > \text{outlier} \geq Q_1 - (3 \times IQR)$$

Furthermore, the temperature data for each layer of the calculation processes is used to calculate the lapse rate (temperature change rate) using the following formula:

$$\gamma = -\frac{\partial T}{\partial Z}$$

Where: Y is the lapse rate, ∂T is the temperature changes, and ∂Z is the height changes.

RESULTS AND DISCUSSION

The lapse rate profile is a representation of atmospheric conditions which aims to see the symptoms that occur and will occur in the atmosphere. Determination of the lapse rate by calculating the change in temperature loss value with altitude at the Gosong Beach, Bengkayang Regency NPP site at 00.00 UTC and 12.00 UTC. Figure 3 shows the lapse rate profile in January at 00.00 UTC and 12.00 UTC showing the same pattern. The lapse rate variation occurs at the bottom of the troposphere (surface up to 600m). The lapse rate at the surface at 00.00 UTC at the bottom layer of the troposphere is up to 0.83 ℃/100 m and at 12.00 UTC it is up to 0.76 ℃/100 m. Meanwhile, the lapse rate profile in February at 00.00 UTC and 12.00 UTC has the same pattern. The lapse rate variation occurs at the bottom troposphere (surface up to 1.6 km). The value of the lapse rate on the surface at 00.00 UTC in the lower layers of the troposphere is up to 1 ℃/100 m and at 12.00 UTC which is up to 0.76 ℃/100 m.

Figures 3 (c) and 3 (d) indicate that the lapse rate profiles in March at 00.00 UTC and 12.00 UTC have the same pattern. Variations in lapse rate occur in the lower troposphere (surface up to 900 m). The lapse rate value in the lower troposphere at 00.00 UTC i.e. up to 0.86 ℃/100 m and at 12.00 UTC which is up to 0.7 ℃/100 m. The lapse rate profile in April at 00.00 UTC and 12.00 UTC also indicating the same pattern. Variations in lapse rate occurs in the lower troposphere (surface up to 2.5 km). Moreover, in the lower troposphere, the lapse rate value at 00.00 UTC is up to 1 ℃/100 m and at 12.00 UTC which is up to 0.8 ℃/100 m.

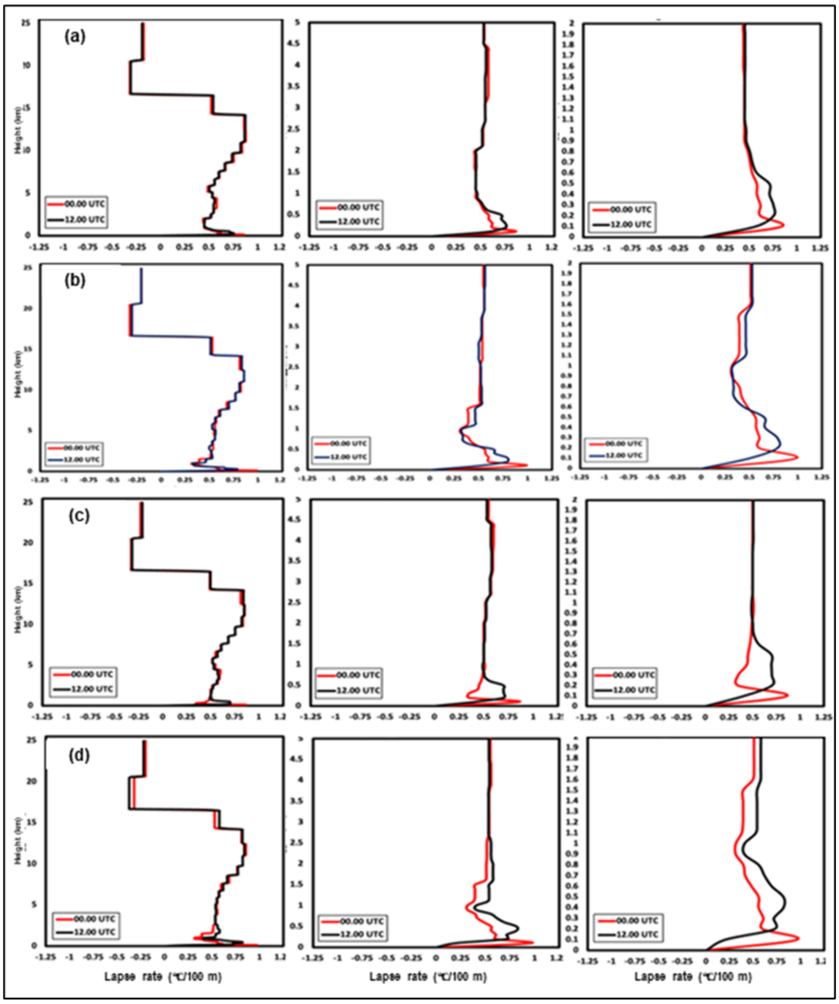

Figure 3. The lapse rate profile for the Gosong Beach, Bengkayang Regency area in 2021: (a) January, (b) February, (c) March, (d) April.

Figure 4 (a) and (b) illustrate the lapse rate profile in May at 00.00 UTC and 12.00 UTC also indicating the same pattern. Variations in lapse rate occurs in the lower troposphere (surface up to 700 m). The lapse rate value in the lower troposphere at 00.00 UTC is up to 0.8 ℃/100 m and at 12.00 UTC which is up to 0.7 ℃/100 m. For further, the lapse rate profile in June at 00.00 UTC and 12.00 UTC also has the same pattern. Variation in lapse rate occurs in the lower troposphere (surface up to 600 m). The lapse rate value at 00.00 UTC in the lower troposphere is up to 0.75 ℃/100 m and at 12.00 UTC which is up to 0.6 ℃/100 m. The lapse rate profile in July at 00.00 UTC and 12.00 UTC has the same pattern. The variation in lapse rate occurs in the lower troposphere (up to 1 km). The lapse rate value at 00.00 UTC in the lower troposphere is up to 0.8 ℃/100 m and at 12.00 UTC is up to 0.75 ℃/100 m. The lapse rate profile in August at 00.00 UTC and 12.00 UTC also showing the same pattern. Variation of lapse rate occurs at the bottom of the troposphere (surface up to 700 m). The lapse rate value at 00.00 UTC at the lower troposphere is up to 0.8 °C/100 m and 12.00 UTC is up to 0.7 °C/100 m as well as shown in Figures 4 (c) and 4 (d).

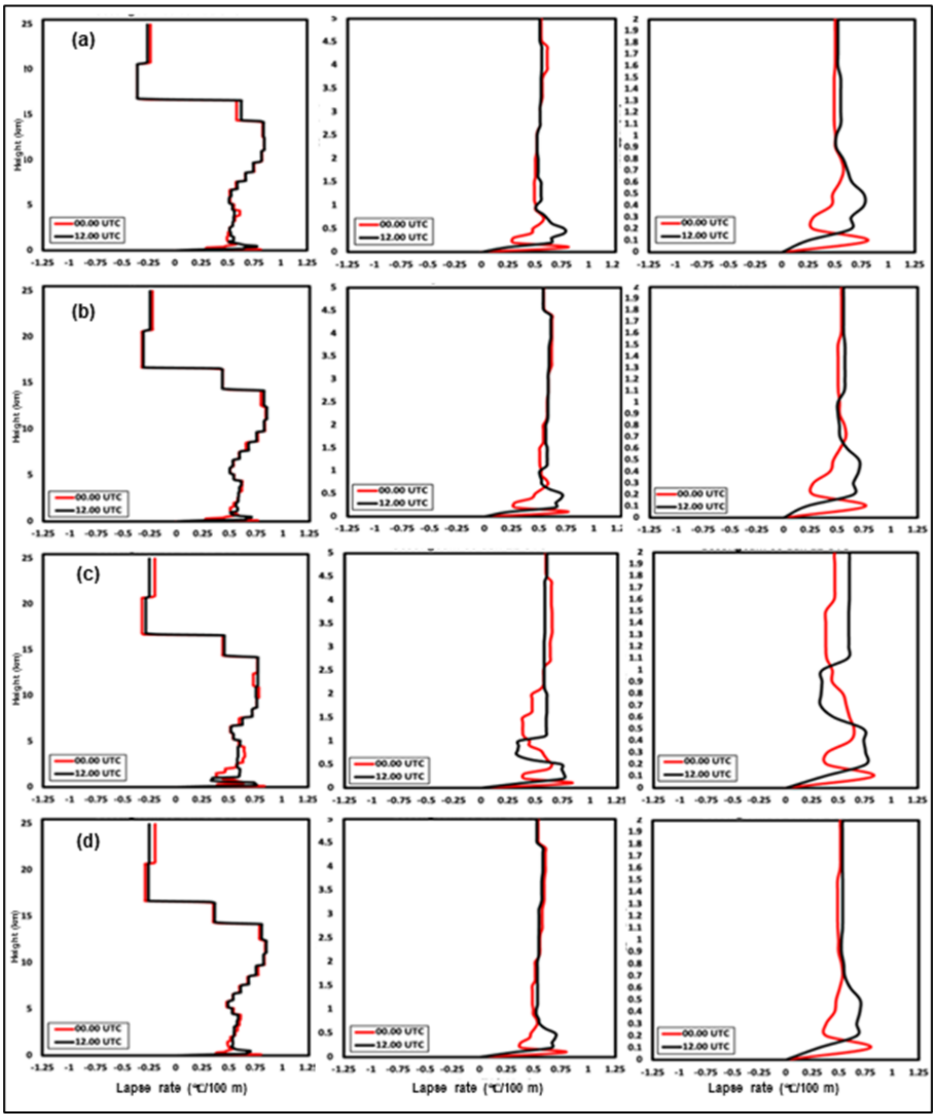

Figure 4. The lapse rate profile for the Gosong Beach, Bengkayang Regency area in 2021: (a) May, (b) June, (c) July, (d) August.

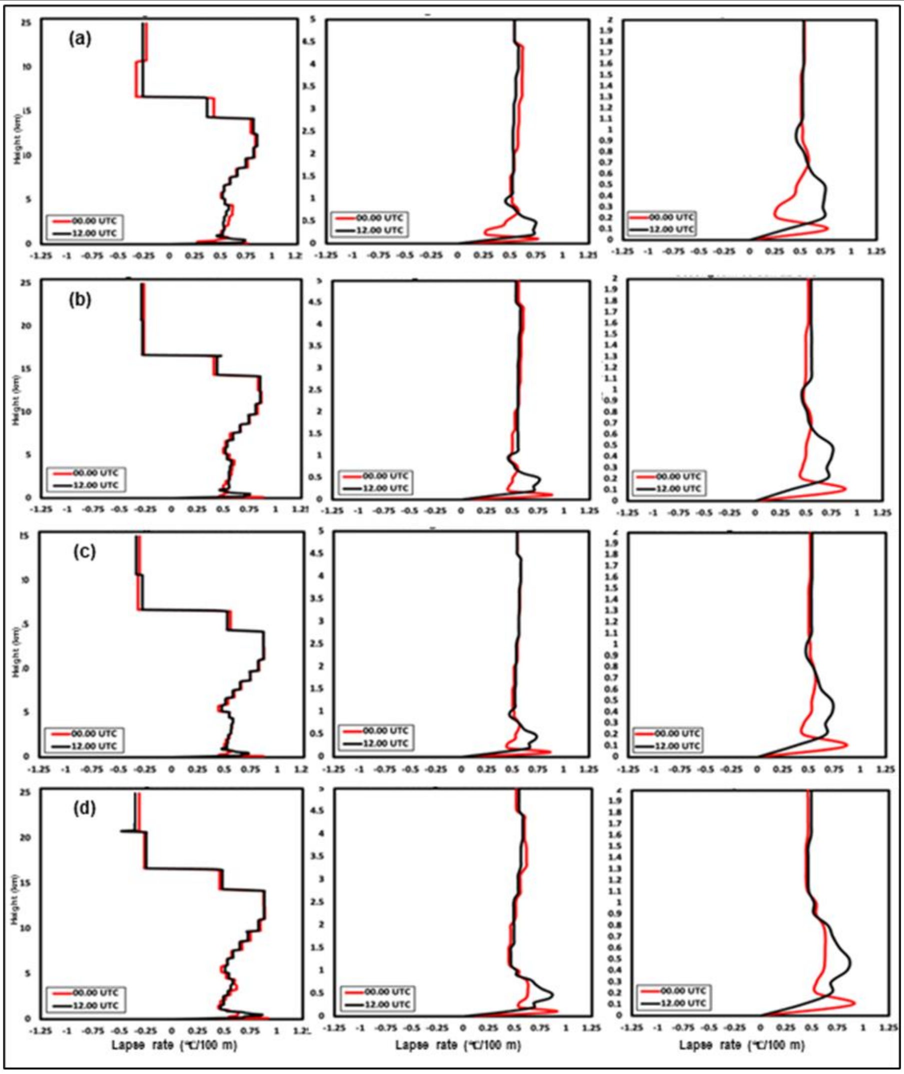

Figure 5. The lapse rate profile for the Gosong Beach, Bengkayang Regency area in 2021: (a) September, (b) October, (c) November, (d) December.

Figures 5 (a) and 5 (b) describe the profile of the lapse rate in September at 00.00 UTC and 12.00 UTC with indicating the same pattern. The variation in lapse rate occurs in the lower part of the troposphere (up to 1km). The lapse rate value in the lower troposphere at 00.00 UTC is up to 0.75 ℃/100 m and at 12.00 UTC is up to 0.75 ℃ /100 m. The lapse rate profile in October at 00.00 UTC and 12.00 UTC also has the same pattern. The variation in lapse rate occurs in the lower part of the troposphere (up to 2 km). The lapse rate value at 00.00 UTC in the lower troposphere is up to 0.87 ℃/100 m and at 12.00 UTC which is up to 0.8 ℃/100 m.

The lapse rate profile in November at 00.00 UTC and 12.00 UTC has the same pattern. Variations in lapse rate occur in the lower part of the troposphere (surface up to 700 m). The value of the lapse rate on the surface at 00.00 UTC in the lower layers of the troposphere is up to 0.86 ℃/100 m and at 12.00 UTC which is up to 0.73 ℃ /100 m. The lapse rate profile in November at 00.00 UTC and 12.00 UTC also indicating the same pattern. Variations in lapse rate occur in the lower part of the troposphere (surface up to 900 m). The lapse rate at the surface at 00.00 UTC in the lower layers of the troposphere is up to 0.90 ℃/100 m and at 12.00 UTC is up to 0.86 ℃/100 m, these is shown in Figures 5 (c) and 5 (d). The value of the variation of the lapse rate profile up to a height of 25 km on the Gosong Beach, Bengkayang Regency can be seen in Table 1 where the maximum lapse rate in 2021 occurs in February, April and December with values of 0.98 ℃/100 m, 0.96 ℃/100 m and 0.90 ℃/100 m and minimum occurs from May to September with a value of 0.83 ℃/100 m - 0.84 ℃/100 m.

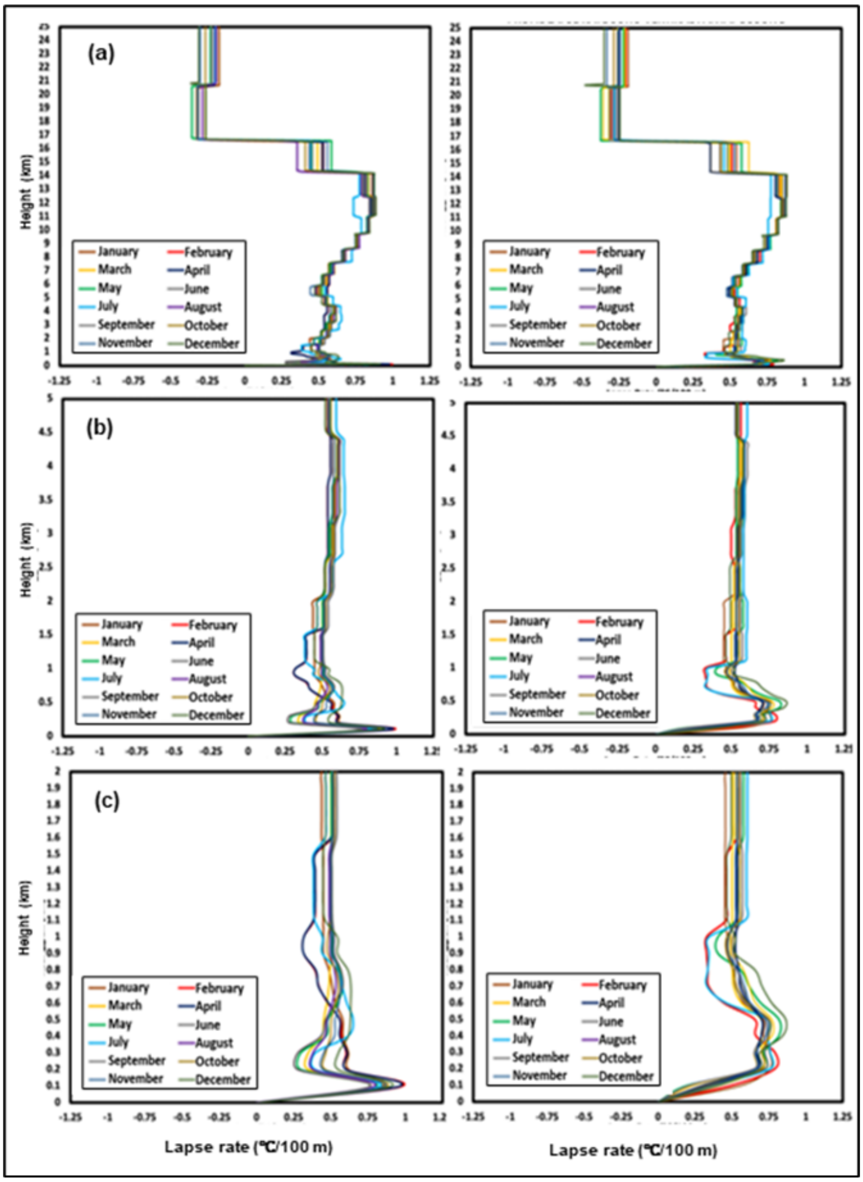

Figure 6. The lapse rate profile for the Gosong Beach, Bengkayang Regency area in 2021 at 00.00 UTC and 12.00 UTC: (a) 25 km, (b) 5 km, and (c) 2 km.

Table 1. The statistical of lapse rate (℃/100 m) at Gosong Beach, Bengkayang Regency.

Time (UTC)	Value	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
00.00	Max	0.87	0.98	0.86	0.96	0.84	0.84	0.83	0.84	0.83	0.87	0.86	0.90
	Min	-0.31	-0.32	-0.32	-0.32	-0.35	-0.32	-0.31	-0.28	-0.32	-0.26	-0.31	-0.36
	Median	0.52	0.52	0.49	0.52	0.55	0.52	0.51	0.49	0.51	0.50	0.55	0.49
12.00	Max	0.87	0.86	0.84	0.83	0.84	0.85	0.77	0.84	0.85	0.85	0.87	0.88
	Min	-0.30	-0.30	-0.32	-0.37	-0.35	-0.31	-0.28	-0.25	-0.26	-0.28	-0.32	-0.48
	Median	0.54	0.51	0.52	0.55	0.54	0.53	0.54	0.52	0.52	0.53	0.53	0.50

The variation of lapse rate in the troposphere at 00 and 12 UTC is in the range of 0.25 °C/100 m to 1 °C/100 m. The variation in lapse rate occurs at the bottom of the troposphere. The Tropopause is characterized by a fixed lapse rate with an average value of -0.3 °C/100 m and at an average altitude of 16.6 km. The stratosphere layer at 00.00 UTC is at an average altitude of 20.5 km with an average lapse rate of -0.21 °C/100 m and at 12.00 UTC, namely 20.7 km and -0.24 °C/100 m. The lapse rate pattern at an altitude of 5 km generally has the same pattern, especially at altitudes between 1–5 km.

The lapse rate profile at 00 UTC in January, February and April in the surface layer up to 200 m ranges about 1 °C/100 m. Furthermore, in March, April, May, June, July and August in the surface layer up to 200 m around 0.75 °C/100 m. Thus, in September, October, November and December generally have the same range of lapse rates which are in the range of 0.25 °C/100 m – 0.5 °C/100 m at 00.00 UTC. However, in December, the lapse rate tends to be higher at surface levels up to 800 m, which is around 0.6 °C100 m. The difference in lapse rate values in January, February and April and December is also at an altitude of 200 m – 600 m ranging from 0.6 °C/100 m while in other months it is around 0.25 °C/100 m to 0.5 °C/100 m. The lapse rate profile at 12 UTC where in the surface layer up to 200 m the lapse rate values are in the range of 0 °C/100 m to 0.6 °C/100 m. This indicates that changes at night are smaller than in the morning because conditions tend to be stable at night and different thermal conditions on the surface. Meanwhile in the 200 m to 500 m layer at 12.00 UTC, the lapse rate ranges from 0.6 °C/100 m to 0.8 °C/100 m, in this layer at 12.00 UTC the lapse rate tends to be higher than at 00.00 UTC. However, at 500 m to 2 km the lapse rate profile gives a nearly identical picture at 00:00 UTC and 12:00 UTC.

CONCLUSION

The West Kalimantan NPP site study was chosen in line with the National Research Program (PRN) roadmap whose main activities include studies for the preparation of NPP blueprint documents, determination of NPP technology, site surveys and feasibility studies, including outreach activities to the community in West Kalimantan. BAPETEN requires several stages of NPP installation site evaluation including collecting data and information related to dispersion; dispersion modeling; radiation dose evaluation; and evaluation of the feasibility of implementing a nuclear preparedness program. Therefore, meteorological data at the site location and its surroundings are an important part of supporting the security and safety of the NPP installation in West Kalimantan. The lapse rate profile is identified by transforming the air temperature data to the altitude of a candidate NPP site at Gosong Beach, Bengkayang Regency. The height of the tropopause is 16.6 km with the stratosphere above 20.6 km. Meanwhile, variations in the value of the profile lapse rate occur at the lower troposphere at an altitude between 100-900 m from the surface. The monthly variability of the lapse rate at 00.00 UTC at an altitude of 200 m has an average lapse rate value between 0.7 – 0.9 °C/100 m. Meanwhile, the lapse rate tends to be lower, between 0.5-0.6 °C/100 m at 12.00 UTC. There is a difference in altitude between 200 m – 600 m, the lapse rate at 12.00 UTC tends to be higher than the lapse rate at 00.00 UTC.

All of the upper air profile data that has been obtained indicates the characteristics conditional atmospheric lability that allow the potential for the growth of convective clouds and triggers of strong winds or tornadoes (puting beliung), However, these values are still within reasonable criteria considering that until now historical data on rare meteorological events such as tornadoes (weak) have not been confirmed to have damaged in the vicinity area of the site candidate.

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REFERENCES

1. Hariyadi. The Agenda-Setting of Nuclear Power Plant Development and Achievement of Electrical Resistance, Study Case in Jepara and Pangkal Pinang. Jurnal Ekonomi dan Kebijakan Publik. 2016;7(2):127–42.
2. Jylhä K, Kämäräinen M, Fortelius C, Gregow H, Helander J, Hyvärinen O, et al. Recent meteorological and marine studies to support nuclear power plant safety in Finland. Energy [Internet]. 2018;165:1102–18. from:

https://www.sciencedirect.com/science/article/pii/S0360544218317936

3. Yuniarto A, Septiadi D. Komparasi stasiun meteorologi calon tapak RDNK dengan kawasan nuklir serpong sebagai upaya memperkaya data pemantauan cuaca dalam proses perizinan. Jurnal Pengembangan Energi Nuklir. 2019;21(2):115–24.
4. Septiadi D, Yuniarto A, Saputra AH. Evaluating meteorological data for nuclear power plant (npp) puspiptek serpong. Jurnal Meteorologi Klimatologi dan Geofisika. 2020;7(3):1–10.
5. Septiadi D, Sugeng Y, Anzhar K, Suntoko H, others. An Extreme Meteorological Events Analysis for Nuclear Power Plant (NPP) Siting Project at Bangka Island, Indonesia. In: IOP Conference Series Earth and Environmental Science. 2018.
6. Dewi D. Risiko konstruksi pada pembangkit listrik konvensional, sebagai masukan untuk konstruksi pltn pertama di indonesia. Jurnal Sains dan Teknologi Indonesia. 2012;14(2).
7. Bluestein HB, Carr FH, Goodman SJ. Atmospheric Observations of Weather and Climate. Atmosphere-Ocean [Internet]. 2022;60(3–4):149–87. Available from: https://doi.org/10.1080/07055900.2022.2082369
8. Navarro-Serrano F, López-Moreno JI, Azorin-Molina C, Alonso-González E, Aznarez-Balta M, Buisán ST, et al. Elevation Effects on Air Temperature in a Topographically Complex Mountain Valley in the Spanish Pyrenees. Atmosphere (Basel) [Internet]. 2020;11(6). Available from: https://www.mdpi.com/2073-4433/11/6/656
9. Hartmann DL, Dygert BD, Blossey PN, Fu Q, Sokol AB. The Vertical Profile of Radiative Cooling and Lapse Rate in a Warming Climate. J Clim [Internet]. 2022;35(19):2653–65. Available from: https://journals.ametsoc.org/view/journals/clim/35/19/JCLI-D-21-0861.1.xml
10. Almethen O, Aldaithan Z. The State of Atmosphere Stability and Instability Effects on Air Quality. Int J Eng Sci (Ghaziabad). 2017 Nov;06:74–9.
11. Wallace JM, Hobbs P v. Atmospheric science: an introductory survey. 2nd ed. 2006. 1–504 p.
12. Pérez Albornoz C, Escalante Soberanis MA, Ramírez Rivera V, Rivero M. Review of atmospheric stability estimations for wind power applications. Renewable and Sustainable Energy Reviews [Internet]. 2022;163:112505. Available from: https://www.sciencedirect.com/science/article/pii/S1364032122004099
13. Tegtmeier S, Anstey J, Davis S, Dragani R, Harada Y, Ivanciu I, et al. Temperature and tropopause characteristics from reanalyses data in the tropical tropopause layer. Atmos Chem Phys [Internet]. 2020;20(2):753–70. Available from: https://acp.copernicus.org/articles/20/753/2020/
14. Md.Khaleelur Rahiman, H.Aleem Basha, K.Thyagarajan. Trends of stability indices over different meteorological stations of India by using IGRA radiosonde data. J Emerg Technol Innov Res. 2017;4(12):513–8.
15. Lin J, Qian T, Bechtold P, Grell G, Zhang GJ, Zhu P, et al. Atmospheric Convection. Atmosphere-Ocean [Internet]. 2022;60(3–4):422–76. Available from: https://doi.org/10.1080/07055900.2022.2082915
16. Susiati H, Dede Moh, Widiawaty MA, Ismail A, Udiyani PM. Site suitability-based spatial-weighted multicriteria analysis for nuclear power plants in Indonesia. Heliyon [Internet]. 2022;8(3):e09088. Available from: https://www.sciencedirect.com/science/article/pii/S2405844022003760
17. Rudas C, Pázmándi T. Consequences of selecting different subsets of meteorological data to utilize in deterministic safety analysis. J Environ Radioact [Internet]. 2020;225:106428. Available from: https://www.sciencedirect.com/science/article/pii/S0265931X20303581
18. Goswami T, Rao SA, Hazra A, Chaudhari HS, Dhakate A, Salunke K, et al. Assessment of simulation of radiation in NCEP Climate Forecasting System (CFS V2). Atmos Res [Internet]. 2017;193:94–106. Available from: https://www.sciencedirect.com/science/article/pii/S0169809517303770
19. Colston JM, Ahmed T, Mahopo C, Kang G, Kosek M, de Sousa Junior F, et al. Evaluating meteorological data from weather stations, and from satellites and global models for a multi-site epidemiological study. Environ Res [Internet]. 2018;165:91–109. Available from: https://www.sciencedirect.com/science/article/pii/S0013935118300926
20. Zaizhong M, Eric S. M, Banglin Z, Tong Z, Sid Ahmed B. Impact Assessment of Himawari-8 AHI Data Assimilation in NCEP GDAS/GFS with GSI. J Atmos Ocean Technol. 2017;34(4):797–815.