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Original Article

ANALYSES OF RADIATION OF ELECTROMAGNETIC WAVES IN THE HIGH-VOLTAGE AIR DUCT (150 kV) CONSTRUCTION ON HEALTH

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ABSTRACT

Background: High-voltage air ducts is the government program to supply electricity needs. However, in practice, obstacles have been identified in the form of rejection from the community due to the outstanding issues that high-voltage air ducts have an impact on health.

Aim: This research aims to analysis the magnitude of electromagnetic wave radiation of high-voltage air ducts construction on health.

Methods: The study was conducted by measuring electromagnetic wave radiation prior to high-voltage air ducts (150 kV) construction and predicting the amount of radiation generated after this operation and its impact on health.

Result: The field measurement result showed that the highest strength of magnetic field in the absence of construction and operation activity of high-voltage air ducts 150 kV was 0.00085 mT and the highest electric field was 0.004241251 V/m. The results of the magnetic field strength analysis showed that the highest strength of magnetic field and electric field when the high-voltage air ducts is completed and operated was magnetic field of 0.00415 mT and electric field of 38.4 V/m. The value was far lower than the standard limits recommended by IRPA / INIRC, WHO1990 and SNI 04-6950-2003. The allowed electric field strength is 5 kV / m and the allowed magnetic field strength is 0.1 mT.

Conclusion: Electromagnetic wave radiation of High-Voltage Air Ducts is not exceeded the allowed limit, so it will not cause a direct risk to health.

Key words: Transmission Line, Magnetic Field, Electric Field, Health

INTRODUCTION

National need for electrical energy experienced an average growth of 10.1% per year. The national electrical energy demand is estimated to increase to about 1,075 TWh by 2031, thus requiring additional national power to be approximately 237,020 MW by 2031. In order to meet these demand, the government established a program of making 35,000 MW of power plants and

transmission lines along 46,000 kilometers of circuits.[1]

The use of high-voltage air ducts transmission network has many advantages such as greater power supply and also power losses in transmission line can be suppressed. Besides the advantages, there are also disadvantages from the use of high-voltage air ducts, one of which is the magnetic field generated by the conductor, which is flowed by electric current. The high magnetic field has caused a lot of anxiety for human health, especially for those who live below or around the high-voltage airway transmission network. Until now, some communities are still worried about living under the Extra High Air Ducts.

Various public negative responses increased against the transmission line development plan, particularly its impact on health. Various studies have shown that high-voltage air ducts are assessed to be a health problem. High-voltage air ducts are assessed to be cancer-trigger[2], can affect the amount of erythrocytes amounts and hemoglobin levels and cause polycythemia[3], affect the growth of animals[4] and plants[5]. In addition, high-voltage air ducts can be considered to worry the public with the phenomenon felt by people living below or around the high-voltage air ducts in the form of light arc, hiss sound, body hair-raising, or pen test and fluorescent lights up[6]. However, until now, no one can ensure that the health impacts mentioned are caused due to electromagnetic waves radiation.[7-9]

Today, there has been no health case reports that can be proven caused by radiation from electromagnetic waves of high-voltage air ducts. Government has set the safe distance for construction of high-voltage air ducts under Regulation of the Minister of Energy and Mineral Resources Number 18 of 2015 concerning the minimum free space and minimum safe distance on high-voltage air ducts, extra high voltage air ducts and high-voltage direct-current air ducts for power distribution. This paper aimed to show the magnetic field magnitude generated due to the construction of high-voltage air ducts with an analysis of the free space required for public health risks.

METHODS

A strong measurement of magnetic field and electric field strength was conducted before existence of high-voltage air ducts construction and operation activity. Magnetic field strength was measured using a *Magnetic Field Meter* (Teslameter or Gaussmeter). While the electric field strength was measured by *Electrical Field Meter*. *Magnetic Field Meter* produces output in Tesla or Gauss units. The *Electric Field meter* generates output in units of V/m.

Measurements were conducted at six points near the high-voltage air ducts which has activity or settlement nearby. Then the measurements were conducted at the conductor sag point between two towers. Measurements must be done by considering some parameters that might affect which is: measuring instrument position, measurement time, weather conditions, the conditions around the measurement point (open field, the presence of trees, the existence of the house etc.).

The magnitude of magnetic field depends on the shape of the current wire and can be calculated by the Biot-Savart law. Determining the value of the magnetic field in x-component and y-component is:

$$H_x(x,y) = \frac{I_c}{2\pi d}\sin(\theta) = I_c \cdot \frac{y-y_c}{2\pi[(x-x_c)^2+(y-y_c)^2]}$$

$$H_y(x,y) = \frac{I_c}{2\pi d}\cos(\theta) = I_c \cdot \frac{x-x_c}{2\pi[(x-x_c)^2+(y-y_c)^2]}$$

The total magnetic field is:

$$|H(x,y)| = \sqrt{|H_x(x,y)|^2 + |H_y(x,y)|^2}$$

The magnitude of the Electrostatics force of interaction between two point charges Q1 dan Q2 is directly proportional to the scalar multiplication of the magnitudes of charges and inversely proportional to the square of the distances between them.

In the transmission line, the electric potential V of the conductor is determined at a certain value. Therefore, the above equation in the previous discussion is used to obtain the charge density ρ of each transmission line conductor. In this case, Equation (6) can be changed to:

$$[\rho]_n = 2\pi\epsilon_0 [P]_{nn}^{-1} [V]_n \quad (C/m)$$

For conductor i, the electric field strength towards point P can be written as follows:

$$\vec{E}_{pi} = \frac{\rho_i}{2\pi\epsilon_0}\left[\frac{(x_p - x_i)\vec{a}_x + (y_p - y_i)\vec{a}_y}{r_i^2}\right] \quad (V/m)$$

whereas for the shadow of conductor i, the electric field towards point P can be written as follows:

$$\vec{E}_{pii} = \frac{\rho_i}{2\pi\epsilon_0}\left[\frac{-(x_p - x_i)\vec{a}_x - (y_p + y_i)\vec{a}_y}{r_{ii}^2}\right] \quad (V/m)$$

so that the total electric field strength at point P, for the number of conductors n, can be written as follows:

$$\vec{E}_p = \sum_{i=1}^{n} [\vec{E}pi + \vec{E}pii] \quad (kV/m)$$

RESULTS

The measurement results at the study sites showed that the highest magnetic field strength before high-voltage air duct 150 kV construction and operation was 0.00085 mT and the highest electric field was 0.004241251 V/m.

The results of magnetic field strength analysis showed that the strongest magnetic field and electric field when the high voltage air duct was completed and operating were the highest magnetic field 0.00415 mT and the highest electric field 38.4 V/m. This value was still far from the standard limits recommended by IRPA / INIRC, WHO1990 and SNI 04-6950-2003. The allowed electric field strength is 5 kV/m and the allowed magnetic field is 0.1 mT.

For more details, the value of electric field strength and magnetic field strength before and after the existing of high voltage air duct can be seen in table 1 and table 2, while for electric field and magnetic field distribution graph can be seen in Figure 1, 2, and 3.

Table 1. Recommendations for exposure limits to electric and magnetic fields

Classification	Electric Field (kV_{rms}/m)	Magnetic Fluctuations Density (mT_{rms})
Occupation:		
1. Whole work day	10	0,5
2. Short Time	30[a)]	5[b)]
3. Limbs	-	25
General environment :		
1. Up to 24 hours/day[c)]	5	0.1
2. A few hours/day	10	1

Tabel 2. Electric field and Magnetic field strength before and after High-Voltage Air Duct construction

No.	Tower	Electric Field Strength (kV/m)	Electric Field Strength in operational (a) (kV/m)	Electric Field Strength in operational (b) (kV/m)	Magnetic field strength (mT)	Magnetic field strength in operational (a) (mT)	Magnetic field strength in operational (b) (mT)
1	TIP 58 and TIP 59	0.00000409156	0.473	0.714	0.00082	0.00439	0.00727
2	TIP 181 and TIP 182	0.00000404 1663	0.471	0.712	0.00081	0.00438	0.00726
3	TIP 208 and TIP 209	0.00000379 2177	0.470	0.711	0.00076	0.00437	0.00725
4	TIP 278 and TIP 279	0.00000384 2075	0.470	0.711	0.00077	0.00437	0.00725
5	TIP 362 and TIP 363	0.00000424 1251	0.474	0.715	0.00085	0.00442	0.00728
6	TIP 411 and TIP 412	0.00000329 3207	0.470	0.711	0.00066	0.00437	0.00725

Notes:
a = With the existence of people working below the transmission sag of 150 kV
b = settlements/houses below the transmission sag of 150 kV V

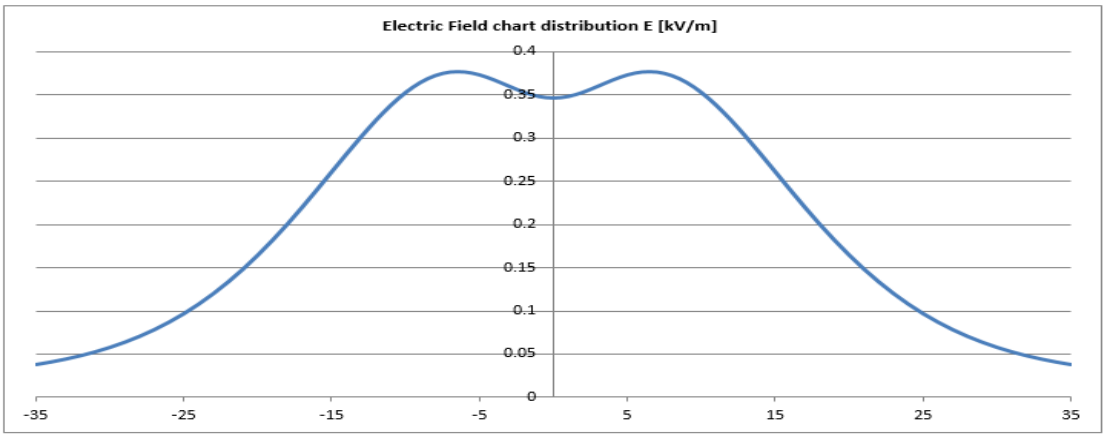

Figure 1. Electric field strength graph in 2D

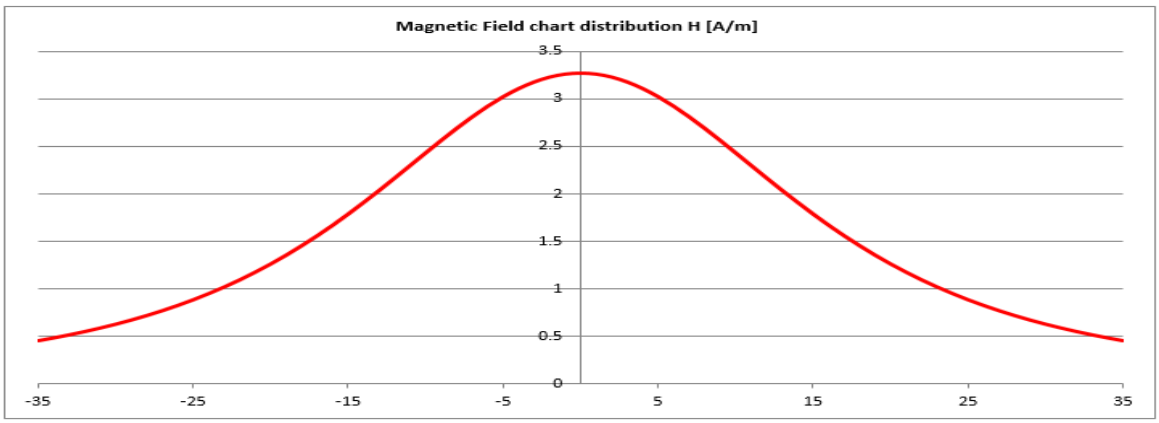

Figure 2. Magnetic field strength graph in 2D

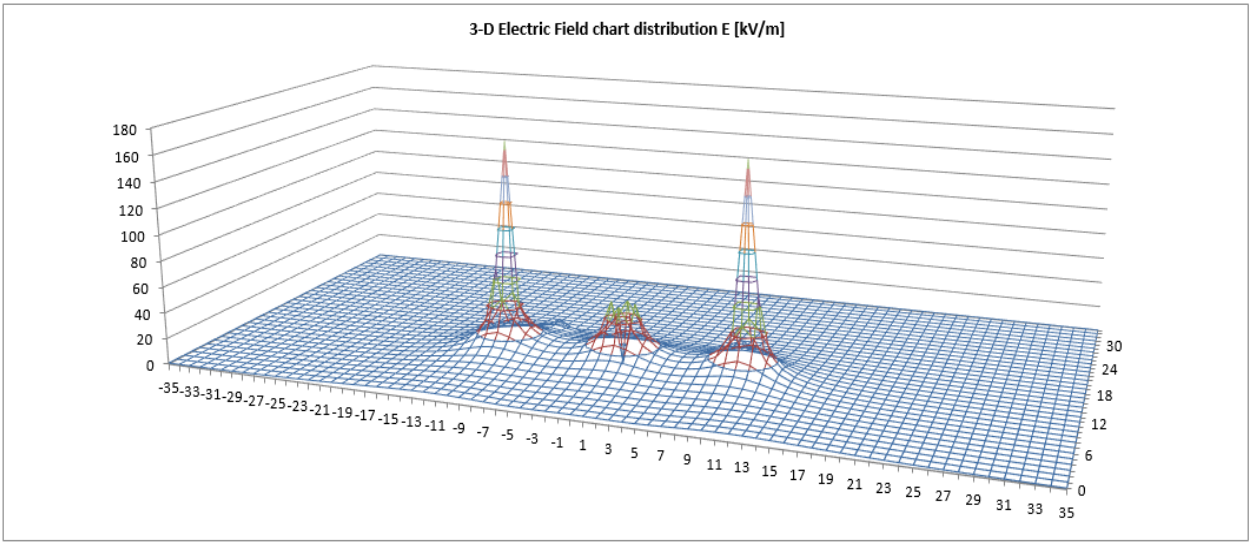

Figure 3. Electric field strength graph in 3D

DISCUSSION

Studies of the health effects caused by electromagnetic radiation have been extensively reviewed since 1950.[10] Epidemiological studies were conducted in electromagnetic wave radiation effect on health, but it is needed to know that everyone receives radiation from various sources and places every day of his life.[13] Health problems can occur due to the influence of heredity, nutrition, health care, behavior and environmental factors.[14] So it is very difficult to determine whether the case of cancer that occurs in the community caused by the network line of high-voltage air duct.[11,12] But until now the impact of electromagnetic wave radiation from this high voltage air duct to public health has not been certainly proven.[13]

Some studies that support it are anxiety disorders due to the presence of high-voltage air duct. Restlessness caused by the loud whirring noise of the cables comes in the rain season. This disturbance of tranquility or restlessness can cause psychological pressure that trigger stress, which ultimately will disrupt the activities of social citizens.[6,14,15] In addition, the high-voltage air ducts building can also disrupt property values in the neighborhood.[16]

The presence of electric fields and magnetic fields around human life cannot be perceived by the human senses, unless the intensity is large enough and felt only by the hypersensitive person. Electrical fields and magnetic fields from high voltage air ducts include non-ionizing radiation groups. This radiation is relatively harmless, completely different from ionizing radiation such as nuclear radiation or x-ray radiation. Both electric field and magnetic field had actually existed since the earth was formed. In clouds containing potential water, there is an electric field that is between 3000-30,000 V/m. Likewise, the earth naturally has an electric field (100 - 500 V / m) and a magnetic field (0.004 - 0.007 mT). An installation system which has voltage and current always generates an electric field. But this electric field has been weakened because the distance is quite far from the source.

The value of electromagnetic wave radiation in construction plan track of high-voltage air ducts is following the Regulation of Minister of Energy and

Mineral Resources No. 18 of 2015 about minimum free space and safe distance from high voltage air ducts, extra high voltage air ducts and direct-current high-voltage air ducts for power supply (Table 3 and Figure 4) are still very far from the standard limit.

Table 3. Vertical Minimum Free Distance from Conductor (cable)

Location	Free Space from 150 kV (m)
Open field or open area[a]	8.5
The areas with the certain conditions	
Building, bridge [b)]	5.0
Plants, forest and vegetation [b)]	5.0
Road/Highway, Railway [a)]	9.0
Public Field [a)]	13.5
Another SUTT, SUTR, SUTM	4.0
The highest point of the ship pole at the highest tide	4.0

Source: Regulation of Minister of Energy and Mineral Resources No. 18 of 2015

Notes:

[a] = *The vertical minimum free distance that calculated from the surface of the earth or road surface/rail*

[b] = *The vertical minimum free distance that calculated from the conductor to the nearest highest point*

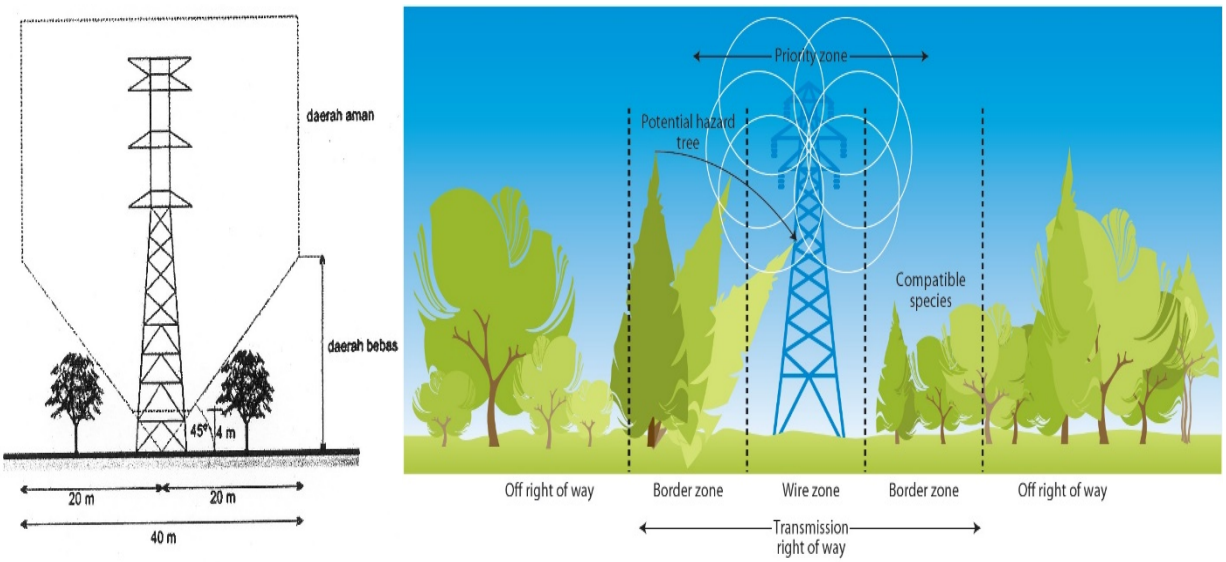

Figure 4. Cross-section of Free Space

The terms of free space and safe space also known in construction of high-voltage air ducts. Free space is a space that must be free of objects and other activities. The free space is set to be differently in size and shape. While safe space is a space outside free space where in this safe space, its land or soils can still be utilized. The effect of electric field and magnetic field strength in the safe space has been considered using reference to valid regulations. The free space and the safe space can be adjusted as needed when preparing the structure design.

Theoretically, if the exposure exceeds the established standard limit, it can cause problems in the blood system (leukemia and lymphoma), reproduction (male infertility, congenital defects, impotence), nervous system (degenerative), cardiovascular system (rhythm change, metabolism changes), endocrine

systems/others (melatonin, bone growth, skin changes)[10 17].

Reducing electromagnetic radiation can be done by adjusting the distance of the sag/network cable according to specified free space safe limits, placing the grounding wire between pasha conductor and ground surface contour[18], conducting an environment-based management to community living below and around high-voltage air duct[6]. Installing a house roof or plafond and planting certain types of plants are inefficient and will not have any significant effect on the reduction of electromagnetic waves radiation.[19 20]

CONCLUSION

The electromagnetic wave radiation of high-voltage air ducts was built in accordance with the Regulation of the Minister of Energy and Mineral Resources No. 18 of 2015 that was not exceeded the standard limit permitted by IRPA / INIRC, WHO1990 and SNI 04-6950-2003, so it will not cause a direct risk to health.

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