

## Application of the R Program for CO<sub>2</sub> Emission Calculations Based on Secondary Carbon Footprint at MTs Bahrul Ulum

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### ABSTRACT

*Global warming is partly caused by the increasing amount of greenhouse gas emissions accumulating in the Earth's atmosphere, leading to a rise in surface temperatures over time. Carbon dioxide (CO<sub>2</sub>) emissions are the main component of greenhouse gases. The largest CO<sub>2</sub> emissions from the energy sector come from using electricity generated by building activities. This study aims to analyze the CO<sub>2</sub> emissions produced from electricity use at MTs Bahrul Ulum. Data collection on electricity usage was conducted by measuring the power consumption of air conditioners, lights, PCs, and laptops used during operational hours, particularly in the MTs Bahrul Ulum school building. CO<sub>2</sub> emissions from the electricity consumption of electronic equipment were calculated using emission factors according to the Directorate General of Electricity, Ministry of Energy and Mineral Resources (ESDM) regulations. The method used is a carbon footprint study. The results show that electricity usage at the location is 6,954.792 kWh/year, and the emissions generated from this electricity usage amount to 8,507.243784 kgCO<sub>2</sub>/year. This study also developed an application using the R program to facilitate the calculation and analysis of CO<sub>2</sub> emissions based on secondary carbon footprints. The application is designed to help users identify and reduce CO<sub>2</sub> emissions resulting from daily activities in the school environment.*

**Keywords:** Global Warming; CO<sub>2</sub> Emissions; Electrical Energy; R Program

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### INTRODUCTION

The environment according to the Law of the Republic of Indonesia Number 32 of 2009 is a unity of space with all objects, power, conditions, and living things, including humans and their behavior that affect nature itself, the continuity of life, and the welfare of humans and other living things. It can be interpreted that there is a close relationship between humans and their environment; humans with all their activities can affect the environment. (Sabardi 2014)

The relationship between living things, especially humans, and their environment is the core of environmental problems. Increasingly consumptive human activities cause environmental changes that threaten the sustainability of the earth. One of the environmental changes that is currently happening is the increasingly hot temperature of the earth's surface. Global warming that occurs is partly caused by the increasing amount of greenhouse gas emissions that accumulate in the earth's atmosphere so that the temperature on the earth's surface increases over time. The main component of greenhouse gas emissions is carbon dioxide gas (CO<sub>2</sub>). (Agnes Sri Mulyani 2021)

The object of this research is MTs Bahrul Ulum Tambak Beras which has the task of implementing human resource development in the field of education. The selection of MTs Bahrul Ulum Tambak Beras as a place of research, because MTs Bahrul Ulum Tambak Beras consumes electrical energy in the use of electronic devices such as lights, air conditioners, computers, photocopiers, printers, etc. to support its operational activities.

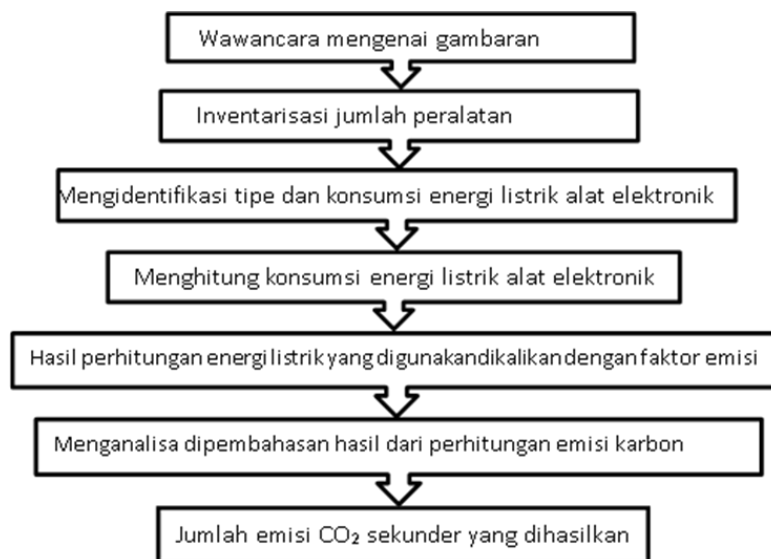
## **METHOD**

### **Type of Research**

In this research, the type of research used is a quantitative research method. Quantitative research is a process of finding knowledge that uses data in the form of numbers as a tool to analyze information about something you want to know. Quantitative research is defined as a research method that uses the process of data in the form of numbers as a tool to analyze and conduct research studies, especially about something that has been researched. It can be concluded that quantitative research is a form of research that uses numerical data collection and analytical techniques to test hypotheses, conclude, and understand the relationships between the variables studied (Nur 2017).

### **Research Stages**

The following research stages are described in the flowchart below:



**Figure 1.** Research Stages

## **Data Collection Methods**

### **1. Data sources**

The data sources in this study are:

#### **a. Primary Data**

Primary data is the main data source in the form of actions resulting from discussions regarding some information obtained from informants by conducting surveys, observations, interviews, and conducting direct calculations on the objects studied (quantitative approach). The primary data in this study are in the form of data on the number of employees, the number of uses of electronic devices (laptops, computers, air conditioners, and lights), and the results of data processing from calculations to determine the amount of electricity consumption and also the amount of secondary CO<sub>2</sub> emissions at MTs Bahrul Ulum Tambakberas

#### **b. Secondary data**

Secondary data is supporting research data that is not obtained from research in the study area, but comes from library studies, the internet, documentation, and literature from related agencies that will be used as supporting data to support primary data processing and conduct analysis in this study. The secondary data required in this study is the CO<sub>2</sub> emission factor data set by the Ministry of Energy and Mineral Resources (KESDM) which is used in calculating secondary CO<sub>2</sub> emissions. (Hasan, Prijanto, and Setyoko 2023)

#### **c. Data Collection Techniques**

After knowing what data sources are needed in this study, namely primary and secondary data, the next step is to collect data which will be listed in the following table.

**Table 1.** Data Collection Techniques

No	Parameter	Data Collection Techniques
1.	General description of the institution (location, number of employees, and research area activities).	Direct observation and survey at the MTs Bahrul Ulum Tambakberas administration building
2.	Several electronic devices (laptops, computers, lights, AC).	Observation and interviews at the MTs Bahrul Ulum Tambakberas administration building
3.	The amount of electrical energy used.	Data processing using electrical power calculations.
4.	The amount of secondary CO2 emissions.	Data processing using GHG emission calculations..
5.	Calculation techniques with the R Program	Data Processing Using the R Program Script

### Analysis Method

After obtaining primary and secondary data, the next step is to process data related to electricity consumption and secondary carbon emissions produced at MTs Bahrul Ulum Tambakberas. The following analysis methods are used:

1. Electricity consumption in everyday life is stated in equation (1), as follows:

$$W = P \times t$$

Description:

W: Electric energy (kWh)

P: Electric power (Watt)

t: Equipment usage time (Hours)

2. Air Conditioner (AC) Electricity Consumption

Calculation of AC electricity consumption and compressor power conversion in AC according to the Regulation of the Minister of Energy and Mineral Resources Number 13 of 2012 concerning Saving Electricity Use, as follows:

AC compressor power conversion:

$$a.1 \text{ PK} = 0.7355 \text{ kW}$$

$$b.1 \text{ HP} = 0.7459 \text{ kW}$$

Electricity Consumption Calculation Formula in AC:

$$WAC = PAC \times \sum AC \times t$$

Description:

WAC: Electricity consumption in AC (kWh)

PAC: Nominal power of AC (Watt)

$\sum AC$ : total installed AC

t: Time of use of AC (Hours)

3. Electrical Energy Consumption of Lamps

The electrical energy consumption of lamps is calculated using the general formula for electrical energy consumption such as equation (1).

4. Energy Consumption of Laptops / Computers

The electrical energy consumption of computers is calculated based on the power supply of the CPU, monitor, and usage time. While for laptops it is only calculated based on the duration of use when the adapter is connected to the power line. The formula for calculating electrical energy consumption on PCs and laptops uses the general equation for electrical energy, namely equation (1). (Rafi and Nisa 2023).

## 5. Secondary Carbon Emissions

The results of the electrical energy consumption are then multiplied by the default emission factor issued by the Ministry of Energy and Mineral Resources to obtain the secondary carbon emission value. The calculation of the secondary carbon footprint can be calculated using the formula equation (2), as follows:

$$\text{GHG emissions} = \sum A_i \times \text{EF}$$

Description:

GHG emissions: greenhouse gas emissions (kgCO<sub>2</sub>)

$\sum A_i$ : The amount of consumption of material type i or the amount of product i. This study specifically focuses on electricity consumption (Wh/kWh/MWh).

EF: Emission factor of material type i or product i. In this study, the emission factor or emission multiplier factor used is the Jamali emission factor in 2016, which is 0.877 kgCO<sub>2</sub>/kWh.

## **RESULT AND DISCUSSION (font size 12pt)**

### **Results**

#### **Location and Brief History**

Madrasah Tsanawiyah (MTs) Bahrul Ulum Tambakberas is located in the Bahrul Ulum Islamic Boarding School environment, Tambakberas Village, Jombang Regency, East Java. This MTs was established to provide Islamic-based junior high school education to students and the surrounding community. Since its establishment, MTs Bahrul Ulum has played an active role in producing generations with noble character and broad knowledge.

#### **Availability of Electricity**

The need for electricity to support teaching and learning activities such as lighting, air conditioning (AC), and electronic equipment at the MTs Bahrul Ulum Tambakberas Office is met by PT. Perusahaan Listrik Negara (PLN). The person responsible for electricity use and electricity payments for the entire MTs Bahrul Ulum Tambakberas Office building is assigned to the finance division.

Electronic Device Usage, Electricity Consumption, and Secondary CO<sub>2</sub> Emissions in the BPSDM Administration Building of the Ministry of Law and Human Rights.

#### **Electricity Availability**

The electricity needs in the BPSDM Administration Building of the Ministry of Law and Human Rights are supplied by a 1600 KVA transformer. The finance division is responsible for electricity usage and payment.

The consumption of electrical energy used in the MTs Bahrul Ulum building such as AC, Lights, PCs, laptops, etc., the availability of the use of electrical energy consumption is:

1. There are 2 AC units with 2 capacities (PK) and 1.5 (PK)
2. Lights, there are 5 lamps with a power of 20 W, and 42 lamps with a power of 15 W, on the 1st floor, on the 2nd floor there are 10 lamps with 20 W and on the 3rd floor there are 2 lamps with a power of 15 W
3. PCs There are 10 PCs with a power of 110 W on the 1st floor
4. Laptops there are 25 laptops with a power of 60 W on the 1st floor.

#### **Electrical Energy Consumption**

##### **AC Electrical Energy Consumption**

Air conditioning in the building uses split AC. The calculation of AC electrical energy consumption on the 1st Floor shows the highest total AC electricity consumption, which is 814.632 kWh per year.

##### **Electricity Consumption of Lamps**

Based on the survey results, electricity consumption from lamps on the 1st Floor reached 1,822.08 kWh per year.

##### **Electricity Consumption of PCs**

The highest electricity consumption for the use of computers/PCs and laptops is on the 1st Floor of the School Building. This is due to the large number of computers and laptops used at that location. from PCs on the 1st Floor reaching 2,745.6 kWh per year, and laptops 374.4 kWh per year

**Table 2.** Electricity Consumption

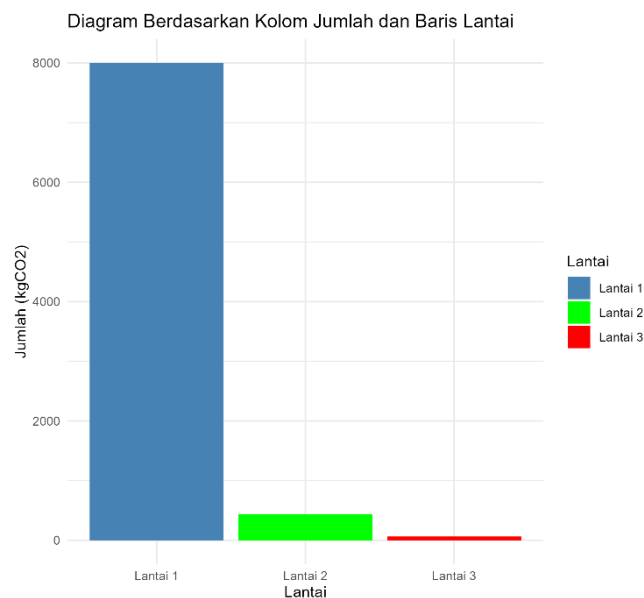
Location	Electricity Consumption (kWh/years)				
	AC	Lamp	PC	Laptop	Amount
Floor 1	814,632	1.822,08	2.745,6	374.4	6.380,712
Floor 2	-	499,2	-	-	499,2
Floor 3	-	74,88	-	-	74,88
<b>Total</b>	814,632	2.396,16	2.745,6	374.4	6.954,792

**Results of Analysis of Calculation of CO2 Emissions from Electrical Energy Consumption**

Data on electrical energy consumption in each electronic device is multiplied by the default emission factor of the electrical energy sector using the R program and produces a total CO2 emission of 8,507.243784 kgCO2 per year.

**Table 3.** Results of Analysis of Calculation of CO2 Emissions

Location	Emission (KgCO2/years)				
	AC	Lamp	PC	Laptop	Amount
Floor 1	714,432264	1597,96416	2407,8912	3283,488	8003,775624
Floor 2	0	437,7984	0	0	437,7984
Floor 3	0	65,66976	0	0	65,66976
<b>Total</b>	714,432264	2.101,43232	2407,8912	3283,488	8.507,243784



**Figure 2.** CO2 Emission Graph Using R Program

**Electrical Energy Problems**

Electricity is a primary need that is very much attached to people's lives. Waste of electrical energy can cause natural resources to decrease and hurt the environment, causing an increase in greenhouse gases and global warming. (Kenedy and Maharani, n.d.).

### **Alternative Solutions to Electrical Energy Problems**

1. Green Building  
Reducing electrical energy consumption by utilizing environmentally friendly and efficient building designs. The application of the Green Building concept includes the use of sustainable materials, efficient energy, and the use of sunlight and natural ventilation.(Widiati 2019)
2. Green Computing  
Implementing the use of environmentally friendly and energy-efficient information technology. This includes the use of computer equipment with the Energy Star logo, managing energy use on PCs/laptops, and recycling old computers.(Hanief, n.d.)

### **DISCUSSION**

This study requires interviews to obtain data related to electricity usage at MTs Bahrul Ulum. The interview results showed a positive response to the use of this R Program to make a data analysis for the future.

### **CONCLUSION**

1. Electricity consumption from the use of AC, lights, computers, and laptops in the MTs Bahrul Ulum Building is 6,954.792 kWh/year. The highest electricity consumption is on the 1st floor, which is 6,380.712 kWh/year. The second highest electricity consumption is on the 2nd floor, which is 499.2 kWh/year. This is because the 2nd and 3rd floors are only used as classrooms. The lowest electricity consumption is on the 3rd floor, which is 74.88 kWh/year, this is because the 3rd floor is only used as a learning room. The largest electricity consumption in the MTs Bahrul Ulum Building comes from the use of AC.
2. Secondary CO2 emissions resulting from the consumption of electricity from the use of electronics are 8,060.392 kgCO2/year. The highest concentration of secondary CO2 emissions is on the 1st floor of the MTs Bahrul Ulum Administration Building. This is because electricity consumption from the use of electronic equipment at this location is greater than others.

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