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Trees Spatial Distribution and Energy Awareness to Reduce Net CO_2 Emission at Universitas Negeri Semarang Campus, Indonesia

ABSTRACT

Energy conservation will be achieved if there is a correlation between human actions in managing energy use and the absorption of emissions, which in this case refers only to CO_2. This correlation will create a comfortable environment. The aims of this study were to: analyze energy consumption in Universitas Negeri Semarang (UNNES) campus, Indonesia, analyze the distribution of trees related to the sequestration of emissions; and understand the awareness of the users of energy in the UNNES campus. Trees were analyzed for their distribution patterns to assess differences in emission absorption between areas with the highest and lowest tree concentrations. Energy consumption to analyze the different human activity levels. The ability to sequester CO_2 emissions was estimated by identifying the spatial distribution of trees. Spatial pattern analysis was employed to establish the human responses to energy management. Although 67% of the UNNES campus comprised of green areas, these cannot absorb the total emissions of 7,862 t yr^{-1}, with 1,573 t yr^{-1} unabsorbed. The green areas extent is unrelated to the number of trees. Trees over 25 cm in diameter have a wide coverage canopy. Still, not all green area distribution patterns were in the form of shade trees, so the emission absorption function is low. Based on the calculations, the 10,264 trees in UNNES can only absorb about 40% of campus activity emissions.

Keywords: *emission absorption, energy consumption, awareness of planting trees, spatial distribution, reduce emission*

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INTRODUCTION

Population growth in this global era is causing increasing problems. Concerns about energy and environmental degradation are becoming increasingly important (*Khan and Asif 2017*). Energy demand is increasing, while natural resources are declining day by day. Population growth and the modernization of civilization are the causes of increasing demand. This can exacerbate global warming caused by energy constraints, gas emissions, and waste generated. Energy limitations, (*Yoro and Daramola 2020; Rehman et al. 2021*). Almost all human activities require energy to meet the needs of households, offices, and industry, for example, all of which use electrical equipment (*Qu et al. 2015*). The energy crisis has become an increasingly important issue today, and the problem of energy has become a worldwide concern.

There are several examples to prevent global warming, such as saving electricity and using alternative fuels rather than those that are fossil-based. Planting trees or reforestation instead of cutting them for inadequate purpose is also an example of preventing global warming. The concepts of reusing, reducing, and recycling combine all those examples into simple ones. The major sources of pollution produced by the internal combustion engine are carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x) and small amounts of sulfur oxides (SO_x), lead (Pb) and particulate matter (*Dey and Mehta 2020*). The industrial sector also produces air pollution, which includes 30 million tons SO_2 every year. Over the past 20 years, there has been a drastic increase in CO_2 caused by fuel combustion, which accounts for a 75% total increase in CO_2, with the remainder contributed by land use changes. Carbon dioxide has the least heating potential, however, it is believed to be the leading cause of global warming. The concentration of CO_2 in the atmosphere reached 417.9 ± 0.2 ppm in 2022 (*Chevallier et al. 2023*). Carbon flow between the atmosphere and vegetation is a two-way process, binding of CO_2 to the atmosphere through decomposition and plants' combustion and absorption of CO_2. Besides CO_2 is also produced from the combustion of oil and gas fuels, which are widely used in urban areas. Each fueloil and gas type has a different level of CO_2 emissions.

Plants are absorbers of CO_2 in the air, and trees have a remarkable ability to do this. Shade trees can absorb emissions; the more comprehensive the shade canopy coverage, the higher the level of CO_2 emissions that can be absorbed (*Kafy et al. 2022*). The more shade trees that are planted, the more CO_2 emissions in the air will be reduced. The trembesi tree (*Samanea saman*) and cassia *(Cassia* sp.) are examples of plants whose ability to absorb CO_2 is notable. Tree plants, including fruit trees, are thought to absorb 0.42 to 0.65 pentagrams of carbon yr^{-1} (*Gelaye and Getahun 2024*). Tamarind (*Tamarindus indica*) trees has also been found to absorb 28,488.39 kg of CO_2 yearly (*Tor-Ngern and Leksungnoen 2020*). Other plants with a high ability to absorb CO_2 include ylang (*Cananga odorata*), banyan (*Ficus benghalensis*), krey umbrella (*Filicium decipiens*), matoa (*Pometia pinnata*) and mahogany (*Swietenia* spp.).

The vision of Semarang State University (UNNES) is to become a university of conservation and international reputation. The conservation vision means protecting natural resources, art, and culture, and forming character values (*Setyowati et al. 2019*). In connection with this vision, UNNES has a policy that every campus user (lecturers, employees, and students) must plant trees. New students must plant one tree, maintain it, and report on its growth for thesis examination requirements. The behavior of planting trees on campus is expected to shape the character of caring for the environment and the willingness to plant trees in the neighborhoods.

The concern of UNNES campus users in using energy is still lacking. Many employees and lecturers still do not turn off their electrical equipment immediately after use. Room lights remain on even when there is incoming sunlight, LCDs and computers are on from morning to evening, and air conditioning is turned on all day. In addition, students, lecturers, and employees use motorized vehicles, even though their homes are around the campus. Energy use related to electricity and transportation produces high CO_2 emissions, and the presence of extensive shade trees on the UNNES campus has not been able to absorb the emissions. Therefore, it is necessary to analyze tree distribution, the ability to absorb emissions at each faculty unit location in the UNNES campus energy use behavior. The use of electricity at UNNES continues to increase yearly, raising the costs to pay for it. The UNNES campus has not conducted good electricity management. Electricity monitoring equipment has not been installed in all buildings, so it is unknown which buildings use the most electricity.

To conserve energy, people can do many ways to use it more wisely and efficiently (*Setyowati et al. 2019*). Energy efficiency reflects behavior to achieve energy savings. Examples of energy efficiency activities include turning off lights and electrical equipment when not in use and adjusting air conditioners to a comfortable temperature that is not too cold. Reducing electricity usage can minimize the impact of air emissions. Human behavior must be improved as humans are the leading cause of increased emissions. Human aspects, including knowledge, attitudes, and behavior towards the environment, can be enhanced by creating cultural awareness of the environment (*Kuśtrowski et al. 2018; Xi-Liu et al. 2018*).

The distribution of trees and energy awareness (management and habits regarding electricity use) reduce CO_2 emissions at UNNES? The research aims to analyze energy use, analyze the distribution of trees for absorbing emissions, and determine public awareness of saving energy.

MATERIALS AND METHODS

Study area

The study was conducted in Semarang State University (UNNES) in Semarang City, Central Java, Indonesia, in 2019-2020. The campus is around 53.70 ha located in Sekaran Village, Gunungpati Sub-district, Semarang Cityincludes nine faculty units, the rectorate, a library and some business units.

The faculty units consist of the Faculty of Education (FIP), Faculty of Language and Art (FBS), Faculty of Social Sciences (FIS), Faculty of Economics (FE), Faculty of Law (FH), Faculty of Mathematics and Natural Sciences (FMIPA), Faculty of Engineering (FT), and Faculty of Sports Science (FIK) (**Figure 1**).

The faculty with the largest land area is the Faculty of Sports Science (FIK), covering 12.28 ha, of which 75.48% is green open space (GOS) and 24.52% is built areas. The Rectorate occupies 10.48 ha, with 62.57% GOS and 37.42% built areas (**Table 1**). The percentage of green open space is obtained from calculations based on field surveys.

Energy use in this study relates to that of electricity (*Fiori et al. 2016*). The research variables include energy consumption then type, number, and distribution of trees. Energy consumption is related to using energy for transportation, generators, and electricity in the campus. The study population composed of lecturers, students,

Figure 1. Research location on the campus of Universitas Negeri Semarang (UNNES), Indonesia.

Table 1. Distribution of built areas, trees and Green Open Space (GOS) in Semarang State University (UNNES) Campus Indonesia.

Faculty	Land Area (m^2)		
	GOS	Building	Total
Faculty of Education Science (FIP)	30,187.44	11,540.47	41,727.91
Faculty of Language and Art (FBS)	32,622.71	31,472.01	64,094.72
Faculty of Social Sciences (FIS), Faculty of Economics (FE), Faculty of Law (FH)	26,932.53	26,117.56	53,050.09
Faculty of Math and Science (FMIPA)	59,569.30	17,644.59	77,213.89
Faculty of Engineering (FT)	52,386.72	20,959.36	73,346.08
Faculty of Sports Science (FIK)	92,700.89	30,121.11	122,822.00
Rectorate Area (KR)	65,574.23	39,215.73	104,789.96
TOTAL	359,973.82	177,070.83	537,044.65

Source: Results of Field Survey (2019)

and administrative staff. A criterion for lecturers was that they were 40-50 years and consequently had a stable life, while administrative staff needed to be 30-40 years old. Lecturers aged 40 and above have relatively stable personal and professional conditions. This contributes to their consistent behavior and attitudes. Additionally, administrative staff aged 30-40 with experience in managing responsibilities, leading them to develop their own decision-making and behavioral styles. These age differences can help explore diverse behaviors and attitudes related to energy use. Students in the fourth and sixth semesters were chosen as respondents because they had taken the Conservation Education course and were familiar with the campus environment. In 2019, the number of lecturers on the UNNES campus was 1,033, and the number of active students was 32,426.

Data were collected through surveys with measurements, data documentation, interviews, and observations. The samples were selected using proportional random and estimation methods for the species and the number of trees. Random proportional samples were used to collect data on participants' awareness of behavior and attitudes toward energy use. Due to limited electricity data, the estimation method was used to collect data on the use of generators and the electricity consumption of UNNES campus users.

Data analysis employed quantitative descriptive methods for spatial analysis. For example, spatial quantitative calculations at each faculty were made to analyze energy consumption and tree absorption. In contrast, spatial percentage analysis was employed to calculate data on habits, attitudes, and concerns about energy.

The following formula was used to calculate CO_2 emissions from gasoline consumption:

$$CO_2 = \text{ADgs} * \text{EFgs} * \text{NCVgs} \quad (1)$$

Carbon dioxide emissions from gasoline fuels (kg), ADgs is the total gasoline consumption (liters). EFgs is is the Emission Factors (kg TJ^{-1}), and NCVgs is the Net Calorific Value of gasoline fuels (TJ l^{-1}) (*Soytas et al. 2007; Shan et al. 2017*).

Carbon dioxide emission analysis was conducted by separating direct emissions (from on-campus sources such as motor vehicles and generators) and indirect emissions (from off-campus electricity production). Direct emissions were calculated using the following formula:

$$CO_2(\text{direct}) = \text{AD} \times \text{EF} \quad (2)$$

where AD is activity data (e.g., fuel consumption) and EF is the emission factor.

Indirect emissions from electricity consumption were calculated using:

$$CO_2\ (\text{indirect}) = \text{EF} \times \text{EC} \quad (3)$$

where EC is electricity consumption (kWh) and EF is the emission factor for electricity generation.

Sequestration by campus trees was compared only to direct emissions, as sequestration occurs within the campus boundary. Indirect emissions were reported separately for context but excluded from sequestration calculations.

Carbon dioxide storage was computed using the number of trees multiplied by CO_2 emissions, using the following formula:

$$CO_2\text{storage} = \text{number of trees} * CO_2 \text{ emissions} \quad (4)$$

This formula was developed from *Tor-ngern's* (*2020*) research on investigating carbon dioxide absorption by urban trees in a new park in Bangkok, Thailand. Distribution patterns reflect resource utilization and environmental tolerance (*Xiao 2015*). The distribution pattern is a consequence of the response to the variation of a phenomenon. The distribution pattern can illustrate the location of the distribution of a variable in space and can be displayed on a map. A graphical display of spatial distributions can summarize raw data directly or reflect results from more sophisticated data analysis. The spatial distribution of energy consumption data is shown graphically. Distribution data are shown in faculty units to be compared to the quantity of the variable data values.

A key limitation of this study is the exclusion of off-campus factors from the sequestration analysis. Indirect emissions from electricity generation, while reported, were not offset within the campus boundary. Future research should explore strategies to integrate renewable energy sources on campus, which could address both local and indirect emissions more effectively.

Additionally, tree species, age, and canopy cover measurements were not incorporated into the estimation, which is another limitation of this study. The estimation of GOS also did not include grassy areas, as these were not considered part of the CO_2 sequestration capacity.

This research focused solely on tree-based sequestration.

Furthermore, the number of trees was calculated based on field surveys and spatial analysis, with GOS coverage providing a basis for estimating tree distribution. The equation for CO_2 sequestration using the 'number of trees' was validated against existing studies that employed similar parameters for tree-based CO_2 absorption estimates.

RESULTS AND DISCUSSION

Energy Consumption and its Emissions at Universitas Negeri Semarang (UNNES) Campus, Indonesia

Three CO_2 emission sources in the UNNES campus are emissions from vehicles that burn fossil fuel, diesel fuel for generators, and electricity consumption. Motorcycle CO_2 emissions are produced by vehicles that consume gasoline and diesel fuel, used as a means of transportation to the UNNES campus area.

The highest number of CO_2 emissions from motor vehicles was from the Faculty of Social Sciences (FIS), Faculty of Economics (FE), Faculty of Law (FH), at 18%, or 245,055.84 kg yr^{-1}. The lowest level came from FIP at 8% or 113,121.44 kg yr^{-1} (**Figure 2**). The level proportional to number of emissions produced by motor vehicles is directly proportional to the number of vehicles, as well as their consumption of fuel.

Carbon dioxide emissions from the use of generators result from the use of diesel fuel. Generators were needed because power cuts often occur at the UNNES campus. Power outages were assumed to be 5 hours per month, with diesel consumption for different generators depending on the generator capacity in each faculty and work unit at UNNES. Carbon dioxide emissions from thelargest generator were 28% or 11,737.44 kg yr^{-1}, relating to the Rectorate, including Building G, Building H, the Auditorium, UPT ICT, LP2M, and LP3. The capacity of the generators in the rectorate area is 100-200 kVA. This large capacity is needed in the area as this is the center of campus service activities. The lowest level of generator emissions came from the Faculty of Sports Sciences, at 3%, or 1,467.24 kg yr^{-1} (**Figure 3**). The high carbon dioxide emissions from the generators in the rectorate area indicate high diesel fuel consumption in the area. It was the highest generator emission observed among the areas.

Electricity is a secondary energy source obtained from converting primary energy sources, for example,

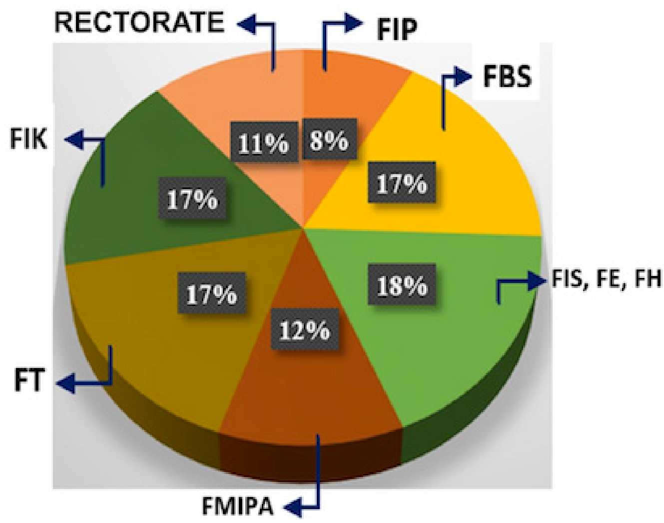

Figure 2. Carbon dioxide emission from motor vehicles in Universitas Negeri Semarang (UNNES) campus, Indonesia (2019).

coal, natural gas, petroleum, and nuclear. Electricity comes from sources that may be renewable or non-renewable. However, electricity is not classified as either renewable or non-renewable energy (*Fiori et al. 2016*). The electricity consumption referred to in this study pertains to the faculties at UNNES campus.

The highest level of emissions from electricity consumption was from the Rectorate area, at 25%, or 1,613,388.36 kg yr^{-1}. The lowest level was from the Faculty of Sports Sciences, at 7%, or 428,280.00 kg yr^{-1} (**Figure 4**). Factors that influence the amount of electricity consumed include the level of electronic equipment used. The highest electricity consumption of all faculties and work units were due to air conditioners. Therefore, the higher the amount of equipment that uses electricity, the higher the emissions produced.

Total carbon dioxide emissions at the UNNES campus were separated into direct emissions (from motor vehicles and generators) and indirect emissions (from electricity consumption). Direct emissions amounted to 1,395,709.34 kg yr^{-1}, while indirect emissions from electricity consumption totaled 6,466,572.22 kg yr^{-1}.

The sequestration potential of campus trees was evaluated against direct emissions only, as these occur within the campus boundary. Trees absorbed 6,457,830.62 kg yr^{-1}, exceeding direct emissions by 5,062,121.28 kg yr^{-1}. However, when indirect emissions are considered, total emissions exceeded sequestration capacity.

Carbon dioxide emissions from electricity consumption are secondary or indirect emissions generated at the study site (*Huang et al. 2022*). In contrast, emissions generated at the electricity production location relate to the power plant site (*Al-Ayouty 2020*). Therefore, emissions from electricity consumption are essential for this study (*Shan et al. 2017*). Furthermore, the electricity consumption on the UNNES campus influences the amount of electronic equipment employed. In this case, the most significant electricity consumption relates to air conditioners.

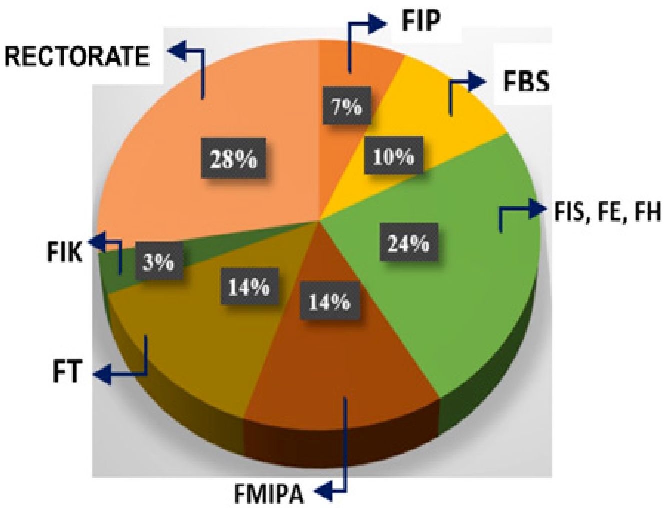

Figure 3. Carbon dioxide emissions from generators in Universitas Negeri Semarang (UNNES) campus, Indonesia (2019).

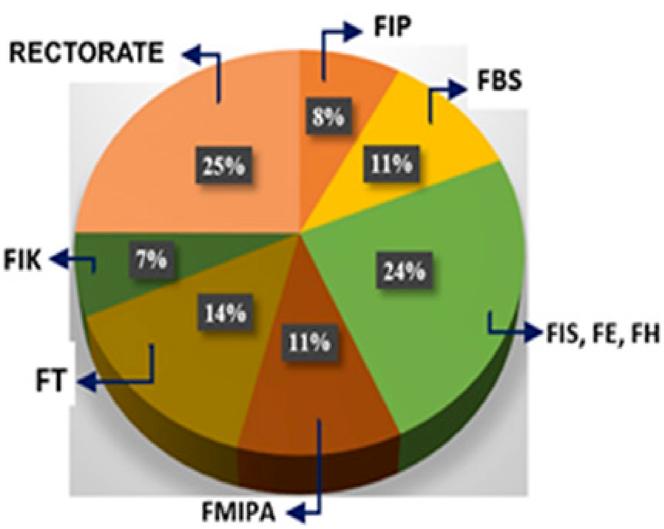

Figure 4. Carbon dioxide emissions from electricity consumption in Universitas Negeri Semarang (UNNES) campus, Indonesia (2019).

The total CO_2 emissions from motor vehicles, using generators, and electricity consumption at the UNNES campus amounted to 7,862,281.56 kg yr^{-1} in 2019. The primary emissions are carbon dioxide from electricity consumption, greater in all the faculties and work units than those from motor vehicles or generators. The largest area of carbon dioxide emissions is the Faculty of Social Sciences, the Faculty of Economics, and the Faculty of Law, amounting to 1,830,682.56 kg yr^{-1}.

Distribution of Trees about Emissions Absorption

The proportion of green open space (GOS) areas on the UNNES campus is 50.81%, which meets the green area requirements of 30% to support environmental quality (*Setyowati et al. 2019; Setyowati et al. 2016*). The size of GOS areas and built areas is almost the same (**Table 2**), with a ratio of 51 to 49. Different faculty units, such as FBS and the combined faculty of FIS, FE, and FH, have the same tendency between GOS and built areas. The largest GOS areas were in the Faculty of Mathematics and Natural Sciences, at 77.14%, followed by FIK (75.48%), FIK (75.48%), FIP (72.34%), and FT (71.42%). The Rectorate area has a GOS area of 62.57% and a built area of 37.42%. The trees have an excellent quantity based on the GOS category and UNNES campus distribution.

The results of the emissions absorption calculation of all the trees on the campus give a total of 6,643,821.63 kg yr^{-1}. The highest absorption is at the Faculty of Sports Sciences, 2,646,523.41 kg yr^{-1}. On the other hand, the lowest absorptive capacity is in the Faculty of

Table 2. Area and tree spread have been fixed: in Universitas Negeri Semarang (UNNES) campus, Indonesia.

Faculty	Area (%)		Total Trees	Trees/ hectares
	GOS	Built		
ö (FIP)	72.34	27.66	1,153	276
Faculty of Language and Art (FBS)	50.90	49.10	1,103	172
Faculty of Social Sciences (FIS), Faculty of Economics (FE), Faculty of Law (FH)	50.77	49.23	1,526	288
Faculty of Math and Science (FMIPA)	77.14	22.85	957	124
Faculty of Engineering (FT)	71.42	28.58	864	118
Faculty of Sports Science (FIK)	75.48	24.52	1,097	89
Rectorate Area (KR)	62.57	37.42	3,564	340
Total =	65,80285714	34,19428571	261,349	

Source: Data Processing Results (2019)

Engineering, at 409,928.93 kg yr^{-1} (**Table 2**). All campus areas have trees so that they can absorb carbon emissions. The total absorption of emissions originating from direct and indirect sources was found in two faculties, namely the Faculty of Education and the Faculty of Sports Science. The School of Sports has two grass field areas, which can contribute to carbon emissions absorption for the faculty. In addition, the Rectorate and the Faculty of Education have a large tree area, which could be called a mini forest.

Trees in the research area can absorb CO_2. However, the quantity and species of trees significantly influence their ability to absorb emissions. The effectiveness of carbon absorption by trees can also be maximized through land management optimization (*Sha et al. 2022*).

These abilities can be differentiated into two types: direct absorption ability of carbon dioxide resulting from motor vehicles and the use of generators, and total absorption ability of carbon dioxide, directly and indirectly, that results from motor vehicles, the use of generators, and electricity. The analysis revealed that the sequestration capacity of campus trees exceeded direct emissions by a significant margin, indicating a net positive impact within the campus boundary. However, indirect emissions from electricity consumption, which originate from external power plants, greatly exceeded the sequestration capacity.

While including indirect emissions provides a holistic view of campus-related emissions, it highlights the limitation of relying solely on local sequestration measures to offset broader environmental impacts. This emphasizes the importance of energy efficiency initiatives and reducing electricity consumption to complement tree-based sequestration efforts.

Direct emissions are 1,395,709,34 kg yr^{-1}, while the absorption ability of trees is 6,457,830.62 kg yr^{-1}. So, the campus has extra absorption of 5,062,121.28 kg yr^{-1}, which would be higher if the fuel consumption of motor vehicles was only based on the campus area.

The overall calculation results cover direct emissions from motor vehicles and the use of generators as well as indirect emissions from electricity consumption. From these results, not all the trees in every unit and faculty at Universitas Negeri Semarang campus can absorb emissions from motor vehicles, generators, and electricity. Only two faculty areas can absorb emissions, Faculty of Education Science (FIP) and Faculty of Sports Science (FIK). Two faculty areas can significantly absorb emissions: namely the Faculty of Education Science (FIP) and the Faculty of Sports Science (FIK). This is partly because the indirect emissions from electricity usage in these areas are the lowest overall. Trees have limitations in absorbing indirect emissions. Additionally, these areas also have higher direct emissions compared to those generated by other faculties. As a result, emission absorption becomes more significant. This is also supported by previous research conducted in different locations, showing that green open spaces can absorb carbon dioxide emissions (*Santoso et al. 2019*). The factors affecting this ability to absorb carbon dioxide include the fact that the indirect emissions in both areas are the lowest overall. Moreover, these areas also have a higher emission than the resulting emission of the faculties.

The tree's ability to absorb emissions at the FIK faculty is caused by the number of trees that are highlyeffective in doing so, such as trembesi (*Samanea saman*), mahogany (*Swietenia* sp.), and teak (*Tectona grandis*). Therefore, although the number of trees in FIK is lower than in the rectorate area, its higher emissions absorption is because of the type of trees. Based on the research, the Trembesi trees can absorb carbon up to 314.28 t ha^{-1} (*Fajariani et al. 2020*). Additionally, research findings indicate that Mahogany (*Tectona grandis*) trees can store carbon amounts to 4,458 g in wood, 3,325 g in leaves, and 1,162 g in bark (*Superales 2016*). The average carbon storage in teak trees is 63.3 MgC ha^{-1}, with 42% stored in harvested wood products (HWPs) (*Chayaporn et al. 2021*).

Campus users' awareness of reducing emissions and energy

According to *Shan et al.* (*2017*) and *Lee et al.* (*2015*), energy provides the opportunity to do business, work, or make changes. Energy enhancement relates to human behavior toward the natural environment. Energy efficiency is reducing the energy needed using energy-related equipment or systems. Energy problems are not only local environmental problems but also global ones (*Xiu-Liu and Qing-Xian 2018*).

Energy saving or conservation is reducing the energy used and utilizing electrical energy as needed. Energy savings can be achieved by using energy efficiently or reducing activities that use energy. The impact of energy savings can reduce costs and increase environmental value, safety, and comfort (*Cariñanos et al. 2019; Lee et al. 2015*).

The analysis of the habits of the lecturers, staff, and students on the UNNES campus is described below.

Lecturers at FIP and FIS, FE, and FH include those who habitually use the lowest electrical energy. In contrast, FMIPA lecturers have the habit of using electricity in the medium category, and lecturers at FBS, FT, and FIK have the highest usage habit (**Figure 5**).

The attitude of lecturers in the use of electrical energy is classified into three types. Lecturers from FIS, FE, FHI, and FMIPA, who are included in the low class; FIP, which is included in the medium class; while those who are included in the high-class category are lecturers from FBS and FT and FIK. The administration [FIS, FE, FH] and LP2M, and the Rectorate area have the lowest awareness of using electricity. FIP, FMIPA, FT, and FIK employees have medium-category electricity usage awareness. Those with the highest understanding of using electricity are from FBS and LP2M. The attitude of FMIPA students toward using electricity is low. In contrast, FIP, FT, and FIK have a medium classification. Students with high categories are those from FBS, FIS, FE, and FH.

Turning off lights and electrical equipment on campus or at home for about one hour/per day will save electricity consumption by around 600 watts per day (*Brounen et al. 2013*). These savings are equivalent to providing electricity to a house in a rural area. Awareness of and concern for electricity consumption must be increased. Saving energy is a simple attitude but one that is difficult to do (*Shan et al. 2017*). If someone is accustomed to saving energy, it will be a lifestyle advantage that benefits life (*Beuttler et al. 2019*).

Energy savings can be made by anyone, anywhere, anytime. Reminding each other to do so is a noble act made by social creatures. The closest people, family, and community should be informed of the importance of saving energy so that needs will be met (*Mansour 2023*). The wise words ‘save electrical energy’ for UNNES people can start with ourselves and simple actions such as turning all the electricity off when they are not used; using energy-saving lamps/LED lamps; setting the air conditioner at 24-26 celsius; close the refrigerator door; rarely open refrigerator doors; reduce the use of washing machines and dryers; develop and make research into alternative energy, such as bio-diesel; and save energy everywhere.

Everyone must try to apply these habitual energy-saving measures anywhere and remind each other. As a social being, it is a noble deed to remind the nearest people, family, or society and inform them of the importance of energy-saving so their goals will be fulfilled.

UNNES campus users’ awareness of reducing electricity usage on campus and at home will reduce emissions. In addition, their attention to the environment, and clean energy, will encourage awareness of the importance of shade trees. Applying the regulation at UNNES for students and lecturers to plant one tree will increase environmental awareness. It is also hoped that UNNES campus users will plant trees in their neighborhoods so that emissions reductions will increase.

A shade tree planting program can be designed cheaply, giving potential savings for the people who plant trees and reducing carbon emissions from energy use in buildings. Each tree can absorb around 10-11 kg of emissions yr^{-1} (*Kafy et al. 2022*). The presence of trees in cities plays a role in absorbing CO_2, which can delay global warming. Biomagnetic monitoring of tree leaves has proven to be a good predictor of ambient particle concentration (*Fraser et al. 2015*).

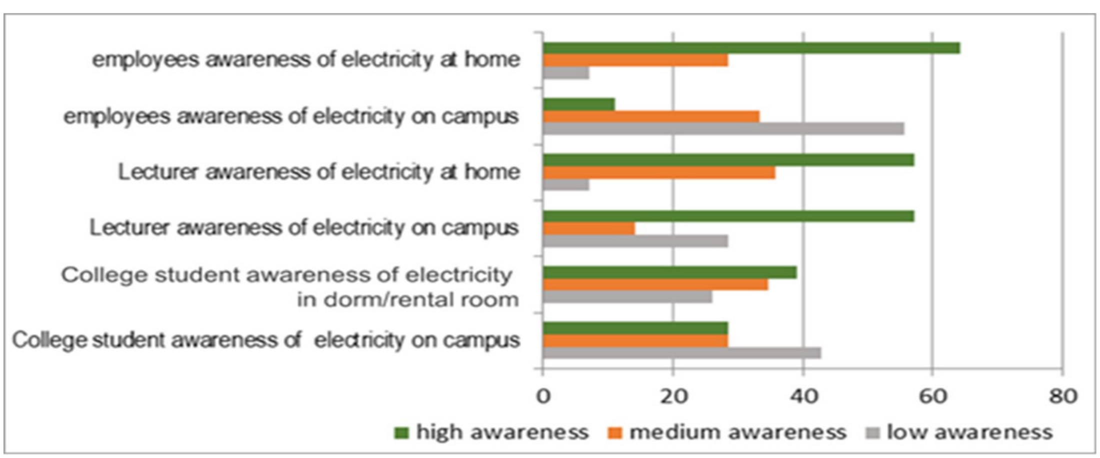

Figure 5. Awareness of Electricity of Students, Lecturers, and Employees of Universitas Negeri Semarang (UNNES), Indonesia.

CONCLUSIONS AND RECOMMENDATIONS

Success in managing and raising energy awareness will result in a culture of sustainable energy savings. An energy-saving culture on campus, a place to work and study, can be translated into using energy at home. An energy-saving culture is a conservation effort, including reducing energy consumption, maintaining clean energy, and controlling emissions. The concept of forming individual energy-saving behavior can be applied sustainably in people's homes, surrounding communities, and in the broader environment, such as urban areas. Reducing urban emissions in the form of energy-saving behavior and implemented by tree planting, the good spatial arrangement of the trees will create clean air in urban areas. Increasing open green space in the form of tree plantations or urban forests will play a role in reducing carbon emissions in urban areas. Energy conservation efforts in utilization, maintenance, and energy protection will work together to create clean air in the campus environment.

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