

# Energy Consumption, Emission Absorption and Carbon Emission Reduction on Semarang State University Campus

Dewi Liesnoor Setyowati, Puji Hardati, Tri Marhaeni Puji Astuti, Muhammad Amin

**Abstract**— Universitas Negeri Semarang (UNNES) is a university with a vision of conservation. The impact of the UNNES conservation is the existence of a positive response from the community for the effort of greening the campus and the planting of conservation value in the academic community. But in reality, energy consumption in UNNES campus tends to increase. The objectives of the study were to analyze the energy consumption in the campus area, to analyze the absorption of emissions by trees and the awareness of UNNES citizens in reducing emissions. Research focuses on energy consumption, carbon emissions, and awareness of citizens in reducing emissions. Research subjects in this study are UNNES citizens (lecturers, students and employees). The research area covers 6 faculties and one administrative center building. Data collection is done by observation, interview and documentation. The research used a quantitative descriptive method to analyze the data. The number of trees in UNNES is 10,264. Total emission on campus UNNES is 7.862.281.56 kg/year, the tree absorption is 6,289,250.38 kg/year. In UNNES campus area there are still 1,575,031.18 kg/year of emissions, not yet absorbed by trees. There are only two areas of the faculty whose trees are capable of absorbing emissions. The awareness of UNNES citizens in reducing energy consumption is seen in change the habit of: using energy-saving equipment (65%); reduce energy consumption per unit (68%); do energy literacy for UNNES citizens (74%). UNNES leaders always provide motivation to the citizens of UNNES, to reduce and change patterns of energy consumption.

**Keywords**—Energy consumption, carbon emission absorption, emission reduction, energy literation.

## I. INTRODUCTION

**I**NCREASED energy consumption on the surface of the Earth is a problem, because the number of people on earth continues to grow. Reference [4] says that energy use is a problem in the world, as increased consumption causes not only greenhouse gas emissions that radically damage the climate but also energy shortages. The production and use of energy is a challenge that requires awareness and adaptation of harmony in every level of society. Energy literacy is an important thing to do, because it awakens awareness and

empowers people to make wise decisions and act responsibly.

Air pollution is a serious problem right now, especially in several big cities in Indonesia; one of them is the city of Semarang [13], [16]. The air pollution will cause natural damage and health problems to human and another organism [15]. Energy has a very important role in people's lives; almost all sectors of life (transportation, industry, offices, households, services, etc.) cannot be separated from energy. The use of energy as an oil fuel becomes a major contributor to air pollution [12] because the fuel contained material endangers human health and damages the environment.

UNNES as an institution of higher education has a vision of conservation and international reputation. One of the themes in the master plan of research and dedication to the UNNES community is conservation [14]. The campus is a place to study, so the convenience of campus environment is one of the main factors supporting the success of student studies. The convenience of the campus is not only determined by the magnificent buildings, but also influenced by the campus layout to realize clean energy.

Electrical energy is now a basic requirement for the community and includes also in the environment of education such as universities. The pattern of user behavior can be identified as a factor that causes increasing electricity use [11], [6]. The efficient use of electricity from all UNNES citizens is needed in order to save the cost of electricity. It is necessary to evaluate the pattern of electricity usage in each Faculty unit at the UNNES. The units that use the most electricity are announced, so that later the Faculty unit leaders will make savings in using electricity.

The main problem that exists on the campus of UNNES is frequent blackouts, disrupting lecturing and administrative activities [14]. Often found electricity that is not used but still burning, air conditioning in the classroom remains lit when no lectures, the computers in the administration room is not used and left on. Some of the events above show that UNNES citizens' concern for electrical energy is still low. Actually, it is also can be done to save electricity usage on the Campus. However, there are still many habits and behavior of UNNES citizen who do not care about electricity use. Campus citizen needs the knowledge and learning about electrical energy through caring and energy saving literacy; expected to increase knowledge. Energy needs on campus UNNES are increasing.

Energy Saving Action is increasingly being encouraged in various countries as a form of concern about the increasingly

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difficult source of energy [3], [6]. In Indonesia, the availability of energy, especially electricity is so very limited; even in some areas, electricity still has not spread evenly [1]. Not only in remote areas, even in big cities, there is often a power crisis so that not infrequently, blackouts in rotation must be done due to the depletion of electricity availability. The same thing happened at the UNNES campus, through research on consumption and emissions on the UNNES, and also literacy UNNES citizens about energy saving. The knowledge and awareness will increase so the energy consumption and emission are reduced and make the campus clean and comfortable.

The objectives of the study were to analyze the energy consumption in the campus area, to analyze the absorption of emissions by trees, and the awareness of UNNES citizens in reducing emissions.

## II. RESEARCH METHODS

The study was conducted at UNNES Campus; the administrative location was in Semarang City, Central Java Province, Indonesia [14]. The research area includes the campus of UNNES Sekaran covering 6 faculties and 1 rectorate.

The focus and object of the study include: carbon emissions on campus UNNES, energy consumption, citizen awareness, behavior and attitudes in energy use, energy literacy. Research subjects in this study were UNNES (lecturers, students and employees).

Data collection is done through observation, interview, and documentation methods. Observation method is to find out electricity consumption on campus. The Interviews were conducted with students, lecturers, employees and faculty leaders at UNNES. Data obtained from interviews include awareness, attitudes, and behavior in energy using. Documentation method is to collect data on the amount of electricity consumption, costs to be paid per month, electricity needs of each UNNES citizen.

The study of population was UNNES citizens, the number of trees in UNNES, and infrastructure facilities that use electricity. The sampling technique is in the form of a 'sampling area', by making observations on each faculty unit, especially the generator data, the use of electric, the numbers of trees. Sampling for UNNES citizens is done by proportional random sampling, to conduct interviews about awareness, behavior and attitudes in energy use.

Data analysis with the quantitative descriptive method, calculates energy consumption and tree absorption. Analysis related to literacy data and concern on energy is calculated by percentage analysis. The formula for calculating electricity consumption [18], [19] is:  $CO^2 = EF \times \Sigma Kwh$ , with the description:  $CO^2$  = emissions from electricity consumption; EF = Emission Factor (0.000586 Ton  $CO^2$ / Kwh);  $\Sigma Kwh$  = Total Electricity Consumption (Kwh).

## III. RESULT AND DISCUSSION

### A. Energy Consumption at UNNES Campus

Energy consumption in the housing sector offers an important opportunity to conserve resources [2]. Understanding the key determinants of residential energy consumption is essential for the design and implementation of effective policies [5].

Carbon dioxide emissions from the use of generators are the result from using diesel fuel for genset operations. Generator sets are usually used to generate alternative power used in the event of a power outage from the State Electricity Company (PLN). PLN's monthly electricity outage is erratic depending on the season and unpredictable damage. Based on data obtained during the study, monthly power outages are assumed for 5 hours with diesel consumption for different generators depending on generator capacity used in each faculty and work unit at UNNES.

The carbon dioxide emissions from the use of the largest generator are located in the Rectorate Area, it happens because the generators in the rectorate area are the largest with a 100-200 KVa capacity. A large number of generating capacity is needed in the Rectorate area, because this is the center of UNNES campus activities. The lowest carbon dioxide emissions are in the Faculty of Sports Sciences. Genset capacity at the Faculty of Sports Sciences is only 5.5 Kva, the electricity needs are the most for administration. Lectures are mostly conducted in the field, in the form of sports activities.

Total carbon dioxide emissions from generator use amounted to 3,545.69 kg/month or 42,548.22 kg/year. The area of carbon dioxide emissions from the use of the highest genset in Rectorate Area is 978.12 kg/month or 11,737.44 kg/year. The amount of carbon emissions in the Faculty of Social Sciences (FIS), Faculty of Economics (FE) and Faculty of Law (FH) amounted to 855.86 kg/month or 10,270.26 kg/year; Faculty of Mathematics and Natural Sciences (FMIPA) of 489.06 kg/month or 5,868.72 kg/year; Faculty of Engineering (FT) of 489.06 kg/month or 5,868.72 kg/year; The Language and Arts Faculty (FBS) is 366.80 kg/month or 4,401.54 kg/year; Faculty of Education (FIP) 244.53 kg/month or 2,934.36 kg/year; the lowest is from the Faculty of Sports Science (FIK) 122.27 kg/month or 1,467.18 kg/year (Table I).

TABLE I  
CARBON DIOXIDE EMISSIONS FROM GENERATOR USAGE

Faculty	Energy Consumption (Tj/Month)	Emission Factor (Kg/Tj)	Kg CO <sub>2</sub> /Year
1	2	3	4=2*3*
FIP	0,00330	74100	2.934,36
FBS	0,00495	74100	4.401,54
FIS,FE,FH	0,01155	74100	10.270,26
FMIPA	0,00660	74100	5.868,72
FT	0,00660	74100	5.868,72
FIK	0,00165	74100	1.467,18
Rectorate Area	0,01320	74100	11.737,44
	Jumlah		42.548,22

The amount of carbon dioxide emissions resulting from electricity consumption at the UNNES campus is 538,881,06

kg/month or 6,466,571.07 kg/year. The largest area of carbon dioxide emission is in Rectorate Area which is 134.449,03 kg/month or 1,613,388.33 kg/year. As for other areas such as FIP, 43,217.69 kg/month or 518,612.25kg/year; FBS of 58,527.05 kg/month or 702,324.66 kg/year; FIS, FE, FH of 131,279.70 kg/month or 1,575,356.46 kg/year; FMIPA of 58,361.80 kg/month or 700,341.63 kg/year, FT of 77,355.80 kg/month or 928,269.57 kg/year and FIK of 35,689.93 kg/month or 428,279.18 kg/year. Details on the number of equipment that uses electrical energy can be seen in Table II.

TABLE II  
CO<sub>2</sub> EMISSION OF ELECTRICITY CONSUMPTION

Faculty	ΣPer month (Kwh)	Emission Factor (Ton/Kwh)	Kg CO <sub>2</sub> /Year
1	2	3	4=2*3*
FIP	73.750,32	0,000586	518.612,25
FBS	99.875,52	0,000586	702.324,66
FIS,FE,FH	224.026,80	0,000586	1.575.356,46
FMIPA	99.593,52	0,000586	700.341,63
FT	132.006,48	0,000586	928.269,57
FIK	60.904,32	0,000586	428.279,18
Rectorate Area	229.435,20	0,000586	1.613.388,33
Jumlah =			6.466.572,07

Source: Data Processing Results, 2017.

The amount of carbon dioxide emissions generated from motor vehicles, generators, and electricity at UNNES is 7,862,281.56 kg/year. The campus area that produces the most carbon dioxide is the FIS, FE, and FH units, as many as 1,830,682.56 kg/year; followed by the Rectorate area (buildings G and H), the area (Auditorium, ICT UPT, LP2M and LP3) produced 1,779,915.72 kg of carbon dioxide/year; the unit FT produced 1.161.306.56 kg/year; FBS produced 940.262,20 kg/year; FMIPA produced 862.318,88 kg/year; FIK produced 653.127,52 kg/year; and FIP Science that is 634,668,08 kg/year.

Carbon dioxide emissions from electricity consumption are secondary emissions or indirect emissions generated at the study site [19], Electricity emissions are important to study [19], but it is not said to be emissions produced at the research site, which means that emissions from electricity do not have a direct impact on the research location, but have an impact on the location of the electricity producer.

Factors affecting the amount of electricity consumption on campus UNNES is the number of electronic equipment that uses electricity to be operated. The largest electricity consumption in every faculty and work unit in UNNES is electricity consumption for AC.

The calculation results show that the total carbon dioxide emissions resulting from motor vehicles, the use of generators, and electricity consumption in the Campus UNNES amounted to 7,862,281.56 kg/year. The greatest emission on the UNNES campus is carbon dioxide emissions from electricity consumption, in all faculties or work units of emissions is the greatest emission when compared to emissions from motor vehicles and the use of generators. While the largest carbon dioxide emissions is in the Faculty of Social Sciences, Faculty of Economics, and Faculty of Law, which is 1,830,682.56

kg/year while the lowest carbon dioxide emissions in the Faculty of Education is 634,668.08 kg/year. Percentage of emission scale of each emission source can be seen in Fig. 1.

TABLE III  
TOTAL CO<sub>2</sub> EMISSION IN UNNES CAMPUS

Faculty	Emission (Kg/year)			Emission (Kg/year)
	Motor Vehicles	Generator	Electricity	
1	2	3	4	5 (2+3+4)
FIP	113.121,44	2.934,36	518.612,25	634.668,08
FBS	233.536,00	4.401,60	702.324,66	940.262,20
FIS,FE,FH	245.055,84	10.270,32	1.575.356,46	1.830.682,56
FMIPA	156.108,56	5.868,72	700.341,63	862.318,88
FT	227.168,24	5.868,72	928.269,57	1.161.306,56
FIK	223.381,12	1.467,24	428.279,18	653.127,52
Rectorate Area	154.789,92	11.737,44	1.613.388,33	1.779.915,72
Jumlah =	1.353.161,12	42.548,40	6.466.572,07	7.862.281,56

Source: Data Processing Results, 2017

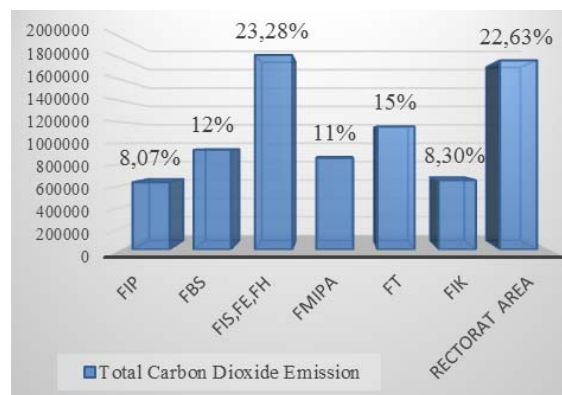


Fig. 1 Percentage Carbon Dioxide Emissions at UNNES

Based on Fig. 1, it is known that the highest percentage of total emissions in UNNES comes from FIS, FE, FH (22.28%). Then the percentage of other regions in a row is the Rector (22.64%), FT (15%), FBS (12%), FMIPA (11%), FIK (8.30%), and FIP lowest at 8.07%.

## 2. The Absorption of Emissions by Trees

Trees in UNNES Campus are spread unevenly on every Faculty and Unit [14]. The highest number of species is 64 in the Faculty of Mathematics and Natural Sciences. The least number of tree species was found in the Faculty of Engineering. The total number of trees on the UNNES campus is 10,264 trees. The Rectorate area has the most trees in UNNES, covering 3,564 trees, and Faculty of Mathematics and Natural Sciences has 957 trees. Data distribution, types, and number of trees served in Table IV.

Each tree in the study site has the ability to absorb different carbon dioxide emissions [9], [1]. The number and type of trees that exist in the research location greatly affect the amount of ability to absorb carbon dioxide emissions [12], [7]. The large number of trees in a region is not a guarantee of the large ability of trees to absorb carbon dioxide emissions because each tree has its own ability to absorb carbon dioxide emissions. Trembesi (*Samanea saman*) and Cassia (*Cassia*

sp.) trees are examples of plants that absorb very large CO<sub>2</sub> up to thousands of kg/year (Table V).

TABLE IV  
TREE DISTRIBUTION AT UNNES

No.	Distribution	Total Kind	Total Tree
1.	FIP	34	1.153
2.	FBS	44	1.103
3.	FIS,FE,FH	30	1.526
4.	FMIPA	64	957
5.	FT	28	864
6.	FIK	32	1.097
7.	Rectorate Area	54	3.564
	Total	286	10.264

TABLE V  
CO<sub>2</sub> EMISSIONS ABSORPTION AT UNNES CAMPUS

Faculty	CO <sub>2</sub> Emission (Kg/year)	Absorbability (kg/year)	Emission Absorption	
			Residual Uptake (Kg/year)	% Absorbed Emission
1	2	3	4 (3-2)	5 (3/2)*100
FIP	634.668,08	637.972,02	3.303,94	100,52
FBS	940.262,20	428.422,64	-511.839,56	45,56
FIS,FE,FH	1.830.682,56	644.114,94	-1.186.567,62	35,18
FMIPA	862.318,88	204.248,05	-658.070,83	23,68
FT	1.161.306,60	409.928,93	-751.377,67	35,29
FIK	653.127,52	2.646.523,41	1.993.395,89	405,2
Rectorate	1.779.915,72	1.318.040,39	-431.322,94	74,05
Jumlah	7.862.281,56	6.289.250,38	-1.573.031,18	79,99

Source: Data Processing Results, 2017

Based on Table V, it is known that the total emission absorption of all trees in the study site is 6,643,821.63 kg/year. Each faculty or work unit has a different dimension of absorption; the highest absorptive faculty is the Faculty of Sport Science with an absorptive capacity of 2,646,523.41 kg/year while the faculty has the lowest absorption is the Faculty of Engineering that has only an absorption of 409.928.93 kg/year.

Based on the above calculation, it can be seen that all the existing areas on the campus UNNES are able to absorb the direct emissions generated in the region. As for the total emissions absorption that comes from direct and indirect emissions, there are only 2 faculties that are able to absorb the total emissions generated in the region, namely Faculty of Education and Faculty of Sport Science. This means not only being able to absorb all emissions, but there are still 2 faculties that have a surplus, especially for the Faculty of Sport Science which has a surplus of 1,993,395.89 kg/year. The total unadjusted emissions on the UNNES campus are 1,404,450.94 kg/year.

Based on the results of the research, the results obtained that not all trees in each Faculty and Unit work in UNNES are able to absorb emissions generated from motor vehicles, the use of generators, and electricity consumption. There are only 2 faculties that are able to absorb the resulting emissions, namely the Faculty of Education and the Faculty of Sports Sciences. The difference in absorption of trees in each faculty and UNNES work unit is caused by electricity use and the

process of electricity emissions. If absorption is calculated only directly from motorized vehicles and generator use, all faculties and work units at UNNES still are able to absorb the emissions produced. In addition to the amount of emissions produced by tree species contained in each Faculty and Work Unit also affect the inability to absorb the emissions produced. The type of tree in the study site is generally the type of tree with the ability to absorb moderate to low emissions.

### 3. Awareness of UNNES Citizens in Reducing Emissions

Electricity is one of the energies that are so important for human life. There is a causal relationship between carbon dioxide emissions, electricity consumption and economic growth [10], [11]. One of the consequences of improving the economy of the community is the changing consumption, pattern of human behavior in using electricity, and all household appliances use electricity. Reference [4] said that people's understanding of energy covers affective and behavioral aspects. Reference [14] stated that conservation values must be owned by UNNES citizens, community behavior and conservation ethics will build the UNNES green campus through concern for around the environment.

References [8], [21] noted that with education, knowledge is more extensive, but that does not automatically imply increased pro-environmental (energy related) attitudes or behaviors. After reviewing models to explain such interactions, they proposed a structure where environmental knowledge, values, attitudes, and emotional involvement constituted a "pro-environmental consciousness" that was embedded in broader personal values. It was shaped by personality and internal factors (motivation, locus of control) and external factors (social and cultural, infrastructure, the political context, economic situations) and pointed towards a nonlinear relationship when cultural and practical concerns were taken into consideration. Such viewpoints were incorporated into the current study.

Habits of students, lecturers, and educational personnel on campus in question in this case are a habit of using electricity on campus [21]. The awareness of students in the high class is the awareness of how the students behave in the use of lights in the classroom and the water faucet in the toilet. Meanwhile, for awareness of the use of air conditioning, use of Wi-Fi, and usage of fans in the campus is still included in the category of low class. The habit of employees in FIS, FE, FH, FIK in using electricity is low; even employees in the rectorate building have the lowest awareness of electricity use; FMIPA and LP2M employees have a good awareness of using electricity, while employees who have the highest awareness of using electricity are at FBS, and the Faculty of Engineering.

The students in FIP and FMIPA have low awareness in using electricity, while the students' awareness in FIS, FE, FH is moderate. Students who have highest awareness in using electricity are found in FBS, FT and FIK. The habit of students in using electricity on campus will be carried away in their homes.

Analysis of the habits of lecturers, employees, and students on the UNNES campus is described as follows. Lecturers in

FIP, FIS, FE, and FH have the lowest habit of using electricity; FMIPA lecturers have moderate electricity usage habits; while lecturers at FBS, FT, and FIK have the best habit in using electricity or can be said to use energy economically.

The results showed that affective attitudes were distinguished in 3 terms, namely lecturers from FIS, FE, and FH, FMIPA including low classes, FIP lecturers included in the middle class, the highest affective attitude was possessed by lecturers from FBS, FT and FIK. Employees at FIS, LP2M, and the Rectorate have the lowest awareness of electricity use. Employees at FIP, FMIPA, FT, and FIK have moderate awareness. Employees with the highest awareness in using electricity are in FBS and LP2M. The affective attitude of FMIPA students in using electricity is still low, FIP students, FT, FIK have a moderate awareness attitude, and students with high energy awareness are students from FBS and FIS, FE, FH.

#### IV. CONCLUSION

The UNNES campus has the largest carbon emissions from electricity consumption, compared to carbon emissions from motorized vehicle transportation and generator use. Most electricity consumption comes from the use of air conditioning. The use of electricity for other equipment such as lights, LCDs, office equipment is only small. Carbon emissions at the UNNES campus have not been absorbed by trees, because the distribution of trees on the UNNES campus is uneven. The regions with the highest carbon dioxide emissions are in the FIS, FE and FH units, the presence of trees in this region is very little. The awareness of UNNES citizens in reducing energy consumption is seen in changing habits: using energy-saving equipment (65%); reduce energy consumption per unit (68%); do energy literacy for UNNES residents (74%). The UNNES leaders must always provide motivation to the citizens of UNNES, to reduce and change the pattern of electricity consumption.

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