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Carbon footprint studies on Esentepe Campus of Sakarya University, Turkey in 2015

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ABSTRACT

The carbon footprint calculation of a university is considered a model role for the rest of other organizations to follow. It is because that a university is full of talented people with diverse experience, advanced research facilities and it consists of many resources that we need to measure, manage and report greenhouse gas (GHG) emissions [1]. In this study, tier 1 methods of the Intergovernmental Panel on Climate Change (IPCC) and setting boundaries method of the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) are applied for calculating GHG emissions from Esentepe Campus of Sakarya University (SAU) in 2015. In the calculation of this study, the last updated Global Warming Potential (GWP) from the IPCC Fifth Assessment Report, 2014 was used for converting greenhouse gases into CO2 equivalent [2]. As a result, Esentepe Campus of Sakarya University released 12,330.73 tons of CO2 equivalents (Expressed as tCO2e) and scope 2 indirect emissions of purchased electricity is the most important emission source, followed by emissions from student and employee commuting. In order to reduce CO2 on Campus, some solutions are also suggested for efficiently consuming electricity and energy.

Keywords: carbon footprint, greenhouse gas emissions, IPCC, setting boundaries, Global Warming Potential.

Sakarya Üniversitesi Esentepe Kampüsü 2015 yılı karbon ayakizi çalışması

ÖZ

Bir üniversitenin karbon ayakizinin hesaplanması benzer organizasyonlar için bir model oluşturmaktadır. Bir kampüste farklı ve çeşitli tecrübelere sahip yetenekli insanlar, gelişmiş araştırma binaları bulunduğu ve çeşitli seragazı kaynakları içerdiği için sera gazı emisyonlarının ölçülmesi, yönetimi ve raporlanması önem arzetmektedir [1]. Bu çalışmada, Sakarya Üniversitesi Esentepe Kampüsünün 2015 yılı seragazı emisyonları Hükümetler Arası İklim değişikliği Paneli'nin (IPCC) tier 1 metodu ve World Resources Institu (WRI) nın sınır belirleme metodu ve World Business Council for Sustainable Development'ın metodları kullanılarak hesaplanmıştır. Hesaplamalarda, 2014 yılı IPCC beşinci değerlendirme raporundaki küresel ısınma potansiyeli, seragazlarını karbondioksit (CO_2) eşdeğerine çevirmek için kullanılmıştır [2]. Sonuçta, Sakarya Üniversitesi Esentepe Kampüsü'nden 12,330.73 ton CO_2 eşdeğeri seragazı açığa çıktığı ve dolaylı emisyon olarak değerlendirilen elektrik tüketiminden kaynaklanan emisyonların en önemli emisyon kaynağını oluşturduğu, bunu öğrenci ve çalışanlardan kaynaklanan emisyonların izlediği bulunmuştur. Kampüsteki CO_2 nin azaltılması için özellikle enerji tüketiminde verimlilik için bazı çözümler önerilmiştir.

Anahtar Kelimeler: karbon ayakizi, seragazı emisyonu, IPCC, sınır belirleme, küresel ısınma potansiyeli

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1. INTRODUCTION

Human activities mainly take responsibility for the release of carbon footprint, namely, greenhouse gases into the atmosphere. As a result, humanity and the natural world would face major threats posed by runaway climate change. However, we can avoid these consequences by reducing emission quantities of individual gases (GHG) with the measurement of Carbon Dioxide Equivalents using the Intergovernmental Panel on Climate Change (IPCC) 100-year Global Warming Potential (GWP) factors [3]. In addition, the potential effects on climate change from different activities can be evaluated on common basis of calculation. In this study, the GHG emissions from each activity within institutional boundaries were converted to CO_2e [3]. Totally, there are 18 greenhouse gases with different global warming potentials. But under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto protocol, there are only six categories of greenhouse gases, which are considered for the purpose of carbon accounting: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorideperfluoro carbon (HFC) and perfluoro carbon (PFC), and sulfur hexafluoride (SF_6) [4].

Similarly, carbon footprint calculation applying Tier 1 and setting boundaries methods are generally carried out by many institutions, such as the case studies of "Carbon Footprint of Faculty of Environment and Resource Studies, Mahidol University, Salaya Campus, Thailand" [5] and "A New Method of Assessment and Equations on Carbon Footprint, Sir Parshurambhau College, India" [6] and "Exploring the applications of carbon footprinting towards sustainability at a UK university" [7]. Those studies were show similar results with our study that universities released similar tons of CO_2 equivalents. It means, electricity consumption was most important factor on carbon foot print in campus.

In Turkey, Bogazici, Istanbul Technical, Ege and Nişantaşı Universities were make some plan or activities for reducing of carbon footprint in their campus, but there is no detail calculation study about campus carbon footprint. In addition, there is a study on Akdeniz University just for Health Services about determination of carbon foot print. This study also was not directly compare with our study because of different method. Although, electricity consumption was most important factor on carbon foot print in Akdeniz University Health Services just as Sakarya University Campus. [8]

2. METHODOLOGY

2.1. Setting Campus Boundaries

The GHG inventory was done on Sakarya University's Esentepe campus located in Serdivan, which includes 834,444 m^2 of occupied areas comprising classrooms, laboratories, libraries, residence halls, dining facilities, athletic and recreational facilities, performance centers, office buildings, and others. In 2015, there were 79,708 students and 2,028 employees on SAU campus. With this number of students and employees, we were allowed to calculate intensity of carbon emissions per capita and per square meter [4].

2.2. Emission Sources and Scopes

To study the campus carbon footprint, either direct or indirect emissions are taken into account. The emissions from sources on campus or institution are called direct GHG emissions and consequences of emissions outside campus or institution are indirect GHG emissions, which are from sources owned or controlled by another company [9]. In this study, three scopes of direct and indirect GHG emissions were applied as follows [9]:

- Scope 1: direct emissions: On-campus stationary fuel source (natural gas usage for heating and cooling)
- Scope 2: indirect emissions: Purchased electricity
- Scope 3: other indirect emissions: Student and employee commute between work and home activities, wastewater, water supply, solid waste, and used paper.

2.3. Spacing

All data needed for calculating GHG emissions on SAU Esentepe campus was collected from SAU administrative offices for the calendar year of 2015. Some data was divided by 12 in order to get the average value for one year, such as average of commuting distance, number of students and employees. We needed to use the average value because number of students and employees and distance of commuting were changed from month to month.

2.4. Calculation

The calculation method of GHG emissions provided by the Intergovernmental Panel on Climate Change (IPCC) was used in the study [10]. This method simply used the multiplication of between activity data and relevant emission factors
$(\text{Emission} = \text{Activity Data xEmission Factor})$.
In addition, the Tier 1 of IPCC was chosen to carry out the calculation of GHG emissions with default emission factors given by various sources as shown in table 1 of emission factors [8]. Moreover, CO_2, CH_4 and N_2O were converted to tCO_2e by using the last updated Global Warming Potential (GWP) values: $(tCO_2e = 1 \times CO_2)$, $(tCO_2e = 28 \times CH_4)$ and $(tCO_2e = 265 \times N_2O)$. [11], [12], [13].

3. RESULT FOR SAU ESENTEPE CAMPUS

In 2015, SAU Esentepe campus emitted 12,330.73 tons of CO_2 equivalents. This result is received by using relevant emission factors and activity data, which are mentioned in table 1 and table 2, respectively:

Table 1: Emission factors for conversion

GHG Emissions Sources	Emission Factors	Unit/Gases
Bus, diesel using engine	2.743243243	Kg/mile CO_2 [9]
Bus, diesel using engine	0.0051	g/mile CH_4 [9]
Bus, diesel using engine	0.0048	g/mile N_2O [9]
Minibus, diesel using engine	0.62654321	Kg/mile CO_2 [9]
Minibus, diesel using engine	0.001	g/mile CH_4 [9]
Minibus, diesel using engine	0.0015	g/mile N_2O [9]
Passenger car, gasoline using engine	0.391555556	Kg/mile CO_2 [9]
Passenger car, gasoline using engine	0.0147	g/mile CH_4 [9]
Passenger car, gasoline using engine	0.0079	g/mile N_2O [9]
Natural gas	1.88496	Kg/m^3 CO_2 [10]
Natural gas	0.000168	Kg/m^3 CH_4 [10]
Natural gas	0.00000336	Kg/m^3 N_2O [10]
Wastewater	0.3	(Kg/liter) CH_4 [11]
Wastewater	0.005	(KgN_2O-N)N_2O[11]
Water supply	0.0014	Kg CO_2e/l [6]
Electricity	0.856	Kg CO_2e/kWh [6]
Solid waste	0.021	Kg CO_2e/Kg [6]
Paper	0.928	Kg CO_2e/Kg [6]

Table 2: Inventories and Activity data

Inventories	Activity Data
Campus area, m^2	834,444
Number of trees on campus	850
Distance of student and employee commuting, Km	20.39
Number of students and employees	81,737
Number of buses	31,286
Number of minibuses	61,275
Number of passenger cars	30,637
Natural gas used for heating and cooling, m^3	1,065,711
Amount of wastewater, liter	33,475
Amount of water supply, m^3	115,405
Amount of used electricity, Kwh	9,416,085
Amount of solid waste, ton (t)	388.95
paper usage, Kg	7,953

During the calculation, all different units were converted into the same standards. For example, 1.609344Km is chosen for 1mile, 1g is equivalent to 0.001Kg, and 1m^3 is for 1000liters of water. By using the same standard of units, then, each of the result was converted into tCO_2e complied with the last updated Global Warming Potential (GWP) values, which are shown in table 3, from the IPCC Fifth Assessment Report, 2014 (AR5) [2]. As a result, amount of GHG scope emissions in tCO_2e was obtained and is illustrated in table 4 and figure 1 according to the GHG Protocol.

Table 3: GWP potential values relative to CO_2:

CO_2	1
CH_4	28
N_2O	265

Table 4: GHG emissions sources in tCO_2e

Scopes	Direct and Indirect Emissions	Emissions CY 2015 tCO_2e
Scope 1	Direct emissions from natural gas usage, stationary combustion	2,014.78
Scope 2	Indirect emissions from purchased electricity	8,060.17
Scope 3	Other indirect emissions	2,255.78
	Student and employee commuting	1,727.77
	Wastewater	350.89
	Water supply	161.57
	Solid waste	8.17
	Used paper	7.38

In addition to having GHG emissions from the scopes, the emissions of all major sources are also presented in percentage in figure 1, figure 2, and in tCO_2e in figüre

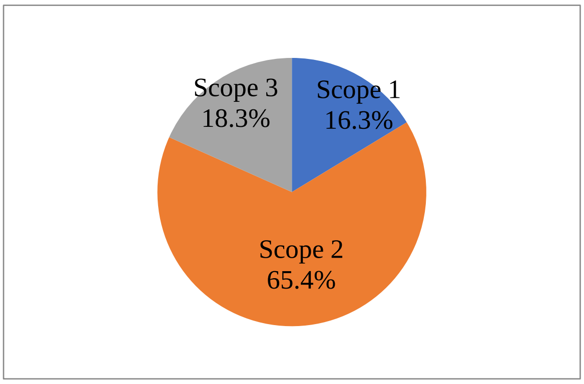

Figure 1: Breakdown of GHG emissions by scopes in percentage

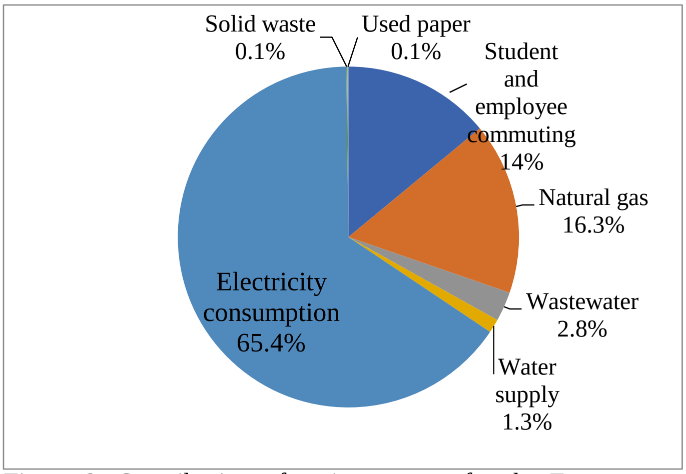

Figure 2. Contribution of major sources for the Esentepe Campus GHG emissions in percentage

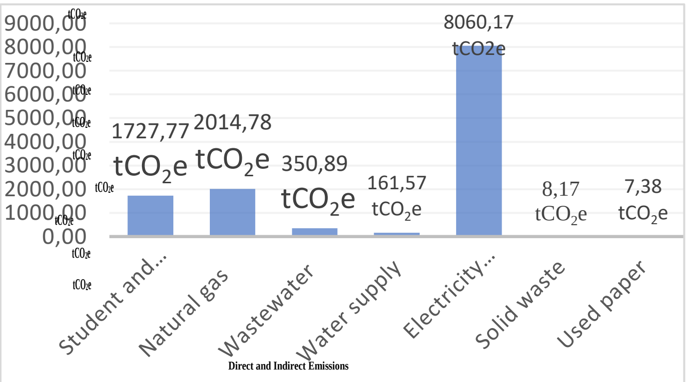

Figure 3. GHG emissions from major sources in tCO_2e

By receiving total amount of tCO_2e emitted by Esentepe Campus, we are also allowed to check out intensity of carbon emissions per square meter and per capita [4], which is demonstrated in table 5.

Table 5: Intensity of carbon emissions

Intensity Metrics	2015
Floor Area	834,444
Tons CO_2e/m^2	0.015
Population	81,737
Tons CO_2e/capita	0.151

In terms of intensity of carbon emissions, the emissions per square meter and per capita for 2015 are 0.015tCO_2e and 0.151tCO_2e, respectively. Additionally, trees can capture CO_2 from the atmosphere, and a single tree can absorb CO_2 at a rate of 22 Kg per year [14]. There are already 850 trees on campus, so it can help reduce 18.7 tons of CO_2. The amount of absorbing CO_2 will be much higher than that, if more trees are planted on campus of Sakarya University.

4. CONCLUSION AND SUGGESTIONS

In 2015, Esentepe Campus of Sakarya University emitted 12,330.73 tCO_2e, in which the electricity consumption was the most CO_2 emitting source, and it accounted for 65.4%. Natural gas usage was responsible for the second place with 16.3% of the total emissions. The least emitting sources were solid waste and used paper, which had almost the same amount of tCO_2e. In other words, the scope 2 emissions shared more than 50% of the total emissions, followed by the scope 3 and the scope 1 emissions. If this study compare to other studies, Sakarya University Campus Footprint is similar to other campuses and also electricity consumption was most important factor on carbon footprint just as other university campus. By the way, it is acknowledgeable that the total amount of CO_2e emitted by Esentepe Campus was not totally accurate. Lack of data from some resource consumptions was one of the challenges for calculating the exact amount of the GHG emissions. Additionally, the emission factors used in the study were taken from three different sources and may affect the outcomes of emissions as well.

It is clear that the usage of fossil fuel, such as coal, oil, natural gas, and gasoline to generating electricity and combustion processes is the factor that leads to emit a huge amount of greenhouse gases, particularly CO_2, which is the most long lived gas compared with other 5 greenhouse gases recognized by the Kyoto Protocol in the atmosphere. However, it is not impossible to find a solution to deal with those emissions from the electricity consumption and combustion. Simply, electricity generated from fossil fuel should be replaced by using alternative energy, such as electricity generated from renewable energy. Other ways to reduce amount of GHGs emitted by electricity consumption is to raise awareness of energy savings or to use energy-efficient light bulbs with models that have earned the Energy Star within campus buildings. Regarding the emissions from both stationary and mobile combustions, the energy efficiency should also be increased. On top of that, Tree carbon sequestration is another simple way to reduce amount of CO_2. This is why reforestation is being focused on the campus. Moreover, to reduce campus carbon footprint, Sakarya University has its new environmental policy, which includes working on energy efficiency, building wind turbines, and waste management studies, and all of these studies will be adopted in the near future.

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