International Journal of Scientific Engineering and Applied Science (IJSEAS) – Volume-7, Issue-2, February2021
ISSN: 2395-3470
www.ijseas.com

Campus Carbon Footprint Study at a South Texas University

Monica Garcia[1], Christian Florez[1], Diego Lopez[1], Jongmin Kim[1,*], Maysam Pournik[1]

[1]University of Texas Rio Grande Valley, Edinburg, TX USA

* Corresponding author

Abstract

A campus carbon footprint study was conducted at the University of Texas Rio Grande Valley, a Southern Texan university. This initiative was the school's strategic plan to set a baseline for overall campus resource utilization status as well as to answer global requests to track and reduce campus greenhouse gas emissions and achieve greater sustainability on campus. For fiscal years of 2016 to 2018, an overall increase of campus carbon footprint was about 0.6%. The biggest increase was observed from sources owned or controlled by the school while the emissions associated with power usage decreased. The university's carbon footprint was greater than other universities in South America while smaller than some peer universities in the western countries. It was found that the university's emissions associated with non-controllable sources including business travel and commuting were the greatest among compared universities. Recommendations were presented to the school, which included many initiatives to reduce campus carbon footprint such as composting, recycling, taking alternative business travel methods, promoting carpool for commute, and better resources consumption data management at the facilities and purchasing departments.

Keywords: *Campus carbon footprint; Campus sustainability; Renewable energy; Greenhouse gas*

1. Introduction

As control of greenhouse gas emissions has become a center of global efforts to prevent and mitigate climate change, an increasing number of US higher education institutions are putting their efforts to study, and document campus carbon emissions associated with their resource consumption. The benefits of conducting data collection of resource consumption and emissions may not be of itself revolutionary, but it can provide a roadmap for institutions to better understand the gaps in data collection and identify where institution resources are being consumed. Also, it helps institutions strategically plan and allocate resource consumptions to reduce the overall carbon footprint of the campus.

One of the universities that utilized a carbon study for the above-mentioned purpose was the University of Cape Town (UCT) in South Africa (Letete et al., 2011). Researchers at the UCT analyzed campus carbon data for the fiscal year of 2007 and found that emissions were about 4.0 tons carbon dioxide (CO2) equivalent per student, which was less than half of South Africa's 2007 per capita emission estimated. They also stated that studying university emissions provided the UCT with a tangible number in comparison with that of other peer institutions and helped set the baseline for future campus carbon reduction plans. The University of Lagos in Nigeria did a case study in reducing the CO_2 emissions of their four dormitories. As a result of the study, the university replaced lightbulbs with CFL types and reduced 45% of CO2 emissions on average from those buildings (Abolarin et al., 2013). In another example, a researcher at the University of Arizona (UA) found that nine campus buildings consumed 80,153,342 Megajoules between 2011 and 2013 at the estimated cost of $2.1 million per year (Chalfoun, 2014). After implementing critical changes to save energy such as reducing energy loss via building exteriors and fine controlling building HVAC and replacing old building components with high-efficiency models, UA was able to achieve an annual energy savings of 10,067,494 Megajoules and a 12.1% reduction in operational cost. Also, the reduced energy consumption removed 2,915 Metric tons of CO2 emission and saved 41,261 m3 of water in a year (Chalfoun, 2014).

Many universities have partnered with private companies to undertake resource utilization studies to better analyze and understand energy consumptions in their campuses. One such company is Sightlines headquartered in South Carolina, USA. The University of New Hampshire in conjunction with Sightlines found that emissions per unit area of 343 US colleges and universities declined by 13% between 2007-2014 with the greatest emission declines occurring when institutions switched fuel from fossil-based to natural gas (Potier, 2015).

1.1 Background

The University of Texas Rio Grande Valley (UTRGV) is a public research university with multiple campuses throughout the Rio Grande Valley of Texas and is a member of the University of Texas System. In 2019, UTRGV has ranked the ninth-largest university

in Texas. Also, UTRGV is one of the largest US universities, of which the majority of the student population (about 89.2%) is Hispanic.

According to the Office of Strategic Analysis & Institutional Reporting (SAIR), four new buildings were added in FY2018 and one building was under construction as of current records. This led to a gross increase in the total campus area from 2,557,704 to 2,593,924 m2 from FY 16 to FY 18. Total enrollment in the fiscal year of 2018 was 28,644, which was a 3.9% increase from the total enrollment of the fiscal year of 2016 (UTRGV Office of Strategic Analysis and Institutional Reporting, 2015,2016,2018).

In 2018, UTRGV commissioned a study of greenhouse emissions across all campuses over the past three fiscal years, 2016 to 2018. A study team was formed with faculties and students from the school of engineering and staff from the office of sustainability partnered with Sightlines for data collection and analysis. The purpose of the study was to set the baseline of UTRGV's long term campus sustainability goal and to optimize resources consumption on campus to cope with global greenhouse gas reduction initiatives. At the time of the study, UTRGV was not practicing composting, recycling, cogeneration, or any type of renewable energy generation/purchase on campus. This paper will outline the successes and future challenges found in the analysis of UTRGV's greenhouse gas emissions.

2. Methodology

Due to the considerable number of different utilization streams, data were divided into three sub-groups, and they are:

a) Scope 1: Emissions from sources owned or controlled by UTRGV that include agriculture, vehicle fleet, on-campus stationary, and refrigerants;
b) Scope 2: Emissions from the generation of the electricity purchased by UTRGV;
c) Scope 3: Emissions from sources not directly controlled by UTRGV include directly financed and study abroad travel, commuting, waste and wastewater, paper purchasing, and transmission and distribution (T&D) losses.

Control and/or mitigation of the emissions get increasingly difficult from scope 1 to 3.

2.1. Scope 1

2.1.1. Nitrogen fertilizer

Fertilizer consumption data were collected by gathering and sorting purchase orders. If the manufacturer was identified, then the labeled product description was taken for the weight per bag. If the weight was not known, then it was assumed to be 22.7 kg per bag as it was typically the standard weight of individual bags for sale from the retailers. After the weight of the fertilizer bag was determined, the percent of nitrogen by weight in the record was multiplied by the weight per bag for nitrogen fertilizer used during the fiscal year of 2016 to 2018.

2.1.2. Fleet fuel consumption

Fleet fuel consumption data were obtained directly from the Texas fleet fuel reporting tool that the university uses to report fleet fuel consumption to the state of Texas as required by law. The types of fuel were also collected, which included diesel, unleaded, and other fluids/additives.

2.1.3. On-campus stationary

On-campus stationary data were provided by the university's accounting department. Data included the type of fuel and amount per fiscal year.

2.1.4. Refrigerants

Work orders filed to the university's accounting department were collected for freon and refrigerants data for the three fiscal years. From the work orders, freon and refrigerants were separated and the amount of each was taken for analysis.

2.2. Scope 2

Scope 2 data were collected from the university's electricity bills.

2.3. Scope 3

2.3.1. Business Travel

The data for business travel were obtained via university travel records. The raw data included locations of the car rentals along with destinations and air miles traveled for the university-related businesses per each fiscal year.

2.3.2. Student/ faculty commuting

Collecting commuting data was challenging as the available data were zip codes of the registered vehicles only. These data did not specify the primary campus that the owner of the registered vehicle commuted to nor the address they were commuting from. Additionally, it was not possible to determine if the owner of the registered vehicle lived on-campus or not. To estimate the commuting distance, the campus that was closest to the zip code of the registered vehicle was assumed to be the location the individual was commuting to. If the round-trip distance was greater than a round trip between the two campuses (~180 km) the data point was discarded as being too impractical to be the actual commuting distance. The final data used for analysis was in a format showing the zip code, the number of permits in that zip code, and the total mileage per that zip code as shown in Table 1. The data point was discarded since the total mileage was greater than the threshold, 180 km.

Table 1. Example of commuting estimate data

Zip Code	Number of permits	km per permit	Total km
78545	1	274	274

2.3.3. Waste and wastewater

Waste data was collected from the university's facility department. Included was the ID number of the dumpster, location, pickup service per week, and size in cubic yards. Annual waste generation was calculated by multiplying the sizes of dumpsters, the number of dumpsters, and the number of pickup services. All were sent to landfills and no recycling was practiced by neither the service provider nor the university at the time of data collection. Also, the local landfill was not harvesting energy by firing landfill gas in the turbine.

Wastewater data was collected from the campus water bills per fiscal year. All wastewater was sent to the local wastewater treatment plant where aerobic treatment was the main treatment method.

2.3.4. Paper purchasing

Paper consumption data were provided by the university's accounting department. All paper purchased was uncoated printing paper for office use and about 10% was manufactured from recycled materials.

2.3.5. T&D losses

Any energy loss during transmitting and distributing from power plants to the customer is T&D losses. For data analysis, 5% of the total energy consumption was assumed to be T&D losses.

2.4. Data analysis

All data were converted to the greenhouse gas emission in a metric ton of equivalent CO_2 (MTCDE) via a web-based campus carbon and nitrogen accounting tool, Sustainability indicator management and analysis platform (SIMAP® at https://unhsimap.org/) developed by the University of New Hampshire.

3. Results

Overall data converted to MTCDE are given in Fig. 1 and details are presented in Table 2. SIMAP®'s sub-categories without data points were removed from the table. The largest emission was from scope 2, 48.8%, $_{avg}$ while scope 1 emission was the least among three scopes with 5.0%, $_{avg.}$ In the 2016 to 2018 fiscal years, overall campus greenhouse gas emissions increased by about 0.6%. The biggest % increase was observed from scope 1 emission while scope 2 emission dropped, which resulted in no significant overall increase. Scope 3 emission did not change for three fiscal years.

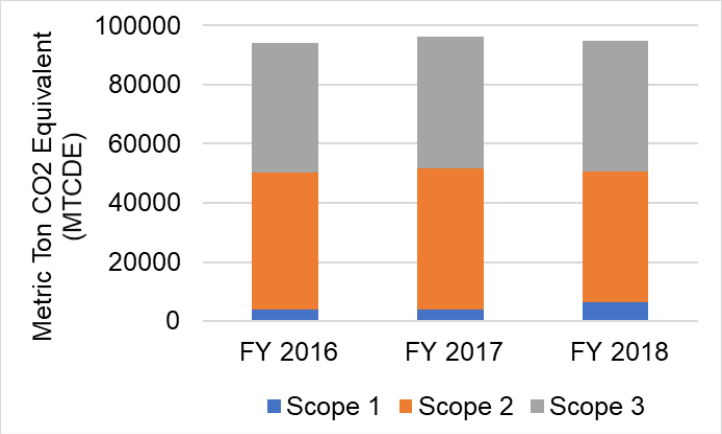

Figure 1. Overall carbon footprint data of UTRGV in FY 2016 - 2018

3.1. Scope 1
Over three fiscal years, scope 1 emission increased by 60.2%. The increase was mainly the result of new building construction on campus and increased student enrollment.

3.1.1. Nitrogen Fertilizer
Only a small portion of the nitrogen-containing fertilizer is absorbed by plants and the rest goes back to the environment. Also, some unused nitrogen fertilizer volatilized in nitrous oxide form (N_2O), of which global warming potential is 298 times greater than that of CO_2.

UTRGV used synthetic fertilizer only during the fiscal year 2016-2018. Most were applied to the soccer field and green areas on campus. The amount of carbon emission from nitrogen fertilizer was 0.21%$_{, avg}$ of overall scope 1 emission for the last three fiscal years.

3.1.2. Fleet Fuel
Over the three fiscal years, carbon emissions from both gasoline and diesel fleet fuel consumption increased by about 70% and this can be attributed to the university's expansion in size and student body from the fiscal years 2016 to 2018 (UTRGV Office of Strategic Analysis and Institutional Reporting, 2015,2016,2018). Also, an increase in the university fleets between two campuses that are 66 miles apart contributed to the increased emission from fleet fuel consumption. According to the analysis, fleet fuel consumption was about 25%, $_{avg}$ of scope 1 emission.

3.1.3. On-campus stationary
On-campus stationary was the biggest emission source of scope 1 emission contributing 62% on average for three fiscal years. Natural gas was the only fuel used for the stationary. There was a total increase of 14.3% in on-campus stationary with one possible cause being the campus expansion with the addition of a new engineering building and several research facilities.

3.1.4. Refrigerant
Refrigerants used on campus were mainly hydrofluorocarbons (HFC-134a), hydrochlorofluorocarbons (HCFC-22). These chemicals are known as strong greenhouse gases.

In fiscal years 2016 and 2017, carbon emissions from the refrigerant were less than 10% but a sudden increase was observed in the fiscal year of 2018. The spike was due to a chiller repair that involved recovery and replacement of HFC-134a. It is temporal and no sudden increase in carbon emission from the refrigerant is expected in the future.

3.2. Scope 2
Electricity was the single biggest contributor to campus carbon footprint during three fiscal years. All electricity was purchased from the local energy producers that were not using renewable sources at the time of the study. Over three fiscal years, scope 2 emission decreased by 3.9%.

3.3. Scope 3

Change of scope 3 emission over three fiscal years was less than 1%.

3.3.1. Student/Faculty Commuting

UTRGV's commuting made up 53.35%, $_{avg}$ of the university's scope 3 emission, producing around 1.4 MTCDE per user. On average 92.7% of the university's student body consists of Rio Grande Valley residents (UTRGV Office of Strategic Analysis and Institutional Reporting, 2015,2016,2018). The average estimated commuting distance to the preferred campus is about 80.7 km per round trip.

Table 2. Data

	Scope 1				
		Direct Transportation Sources		On-Campus Stationary	Refrigerants
	Fertilizer	University Fleet			
Fiscal Year	Synthetic	Diesel Fleet	Gasoline Fleet	Natural Gas	HCFC, HFC, etc.
	MTCDE	MTCDE	MTCDE	MTCDE	MTCDE
2016	10.7	119.6	659.6	2,965.8	222.6
2017	7.5	253.2	1,089.6	2,305.6	353.1
2018	11.0	332.5	985.8	3,390.1	1652.8

	Scope 2
	Electricity
Fiscal Year	Electricity
	MTCDE
2016	46,130.8
2017	47,635.4
2018	44,229.5

	Scope 3							
	Commuting		Directly Financed Outsourced Travel		Paper	Solid Waste	Wastewater	
	Faculty	Student	Air			Landfilled Waste	Central Treatment System	
Fiscal Year	Auto-mobile	Auto-mobile	Faculty / Staff	Personal Mileage Reimbursement	Uncoated Freesheet	No CH_4 Recovery	Aerobic	T&D Losses
	MTCDE	MTCDE	MTCDE	MTCDE	MTCDE	MTCDE	MTCDE	MTCDE
2016	3,652.3	24,348.5	7,749.6	107.2	103.7	5714.5	44.5	2,371.8
2017	4,034.9	23,852.6	8,194.1	141.1	93.4	5714.5	42.8	2,449.1
2018	4,205.6	22,597.2	9,010.9	137.9	114.0	5714.5	46.5	2,274.0

3.3.2. Business Travel

Over three fiscal years, emissions from business travel contributed 19.1%, $_{avg}$ of scope 3 emission. The increase per each fiscal year was about 8%. The majority of the carbon emission from business travel was from air travel. Mileage reimbursement was less than 2% of total emissions from business travel per fiscal year.

3.3.3. Paper
Minute contribution to scope 3 emission was measured from paper purchase, averaging 0.23% for three fiscal years.

3.3.4. Solids waste and wastewater
No carbon recovery was practiced by the local landfills, which resulted in relatively large emissions from solids waste. Since the amount of waste generated on campus was calculated by multiplying the frequency of pickups, size, and the number of dumpsters, emission from the solid waste did not change for the last three fiscal years. Emissions associated with solids waste was 12.9% of scope 3 emission.

All the wastewater from UTRGV was treated at the centralized local wastewater treatment plants. None of them were practicing energy recovery at the time of the study. Carbon emission from wastewater was $0.1\%_{, avg}$ of scope 3 emission during the last three fiscal years.

4. Discussions

4.1 Scope 1

4.1.1. Nitrogen Fertilizer
Two bulk fertilizer purchases were very challenging to track since they were not logged in the database like other fertilizer purchases. They were marked as numbers of bags without any details. Each purchase order made during the two bulk fertilizer purchases was looked at to comb through the photocopied receipts which included the weight of each fertilizer used and percent nitrogen of each fertilizer used. More detailed data logging was recommended to the university's purchase department to help future data collection. Suggested was to keep the project number linked with the precise purchase and work orders with detailed information such as the weight per unit of measure, organic or synthetic, and the nitrogen contents with the total weight.

Additional recommendation to the university was to utilize more native landscaping with local flora such as cacti to reduce fertilizer purchases. This can provide an opportunity for reduced watering and fertilizing (from 5-10%) as these are native plants adapted to the dry climate in South Texas.

4.1.2. Fleet Fuel Consumption
With the increase of student enrollment, fleet fuel consumption increased by about 70% during fiscal years 2016 to 2018. Fleet fuel consumption may not decline in the future since UTRGV's student enrollment rate has grown steadily, thus frequencies of trips and number of commuting students between two major campuses in university's fleets have increased accordingly.

One possible avenue to explore is to convert more fleet vehicles to hybrid and/or electric, which will lead to reducing fleet fuel consumption. Such a conversion has the potential for an increase in social capital as an institution that embraces environmental conservation. Besides, this change may result in cost-saving. In the year 2018, New York City announced that they saved a considerable amount of maintenance cost by changing city fleets from fossil fuel to electric cars (Kerman, 2019).

4.1.3 Refrigerants
In fiscal years 2016 and 2017, carbon emissions from the refrigerant were less than 10% but a sudden increase was observed in the fiscal year of 2018. The spike was due to a chiller repair that involved recovery and replacement of HFC-134a. A similar spike of carbon emission from the refrigerant is not expected in the future since it will be years left till the next chiller repair is required.

However, it may be fruitful to pursue efforts in reducing consumption to counter any uptick in usage such as reducing stress on air conditioning units. This can be done by moving thermostats a few degrees up along with utilizing timers that adjust the temperature overnight when comfort is not an issue.

4.2 Scope 2
Electricity consumption was the biggest contributor to the campus carbon footprint. Although UTRGV campus and student enrollment have continuously expanded, overall electricity consumption decreased by 3.9% over the three fiscal years. University's efforts to save energy may have attributed to the decrease. UTRGV has been changing light fixtures to energy-efficient models and turning off lights in unoccupied classrooms.

Any reduction in energy use on campus will impact the university's overall carbon footprint since scope 2 was the biggest single contributor to campus carbon emission in UTRGV. An avenue for improvement would be exploring any opportunity to purchase part of electricity, if not whole, from renewably generated and/or co-generated sources if it is deemed feasible to the institution. Currently, UTRGV is seeking an opportunity to purchase renewable energy from the local solar power generator.

4.3 Scope 3

4.3.1 Business Travel

Only two types of data were available at the university's accounting department, rental car mileage, and air travel. Additional data collection for business travel was recommended to the school, which includes other modes of transportations such as train, taxi, bus, and personal mileage reimbursement. However, encouraging conservation for business travel does not have as much room to improve as the institution is not usually capable of limit faculty and students' travel to academic occasions such as conferences and study abroad. It is more realistic for the university to encourage travelers to utilize public transportation when they can travel in groups like carpooling to reduce fuel consumption per person.

4.3.2 Student/Faculty Commuting

Commuting data was the most challenging to collect since the university was not accruing any data at the time of the study. An issue with the data analysis is that it is presumptive to use the distance between the zip code and the closest campus as the commuting distance. Compounding this assumption with the sheer number of data points (more than 20,000 permits) the results well likely depict a much different commuting trend than the actual commuting habits of faculty and students. A potentially impactful method of curbing emissions from commuting to the university is allowing for students and faculty to purchase special parking permits for two or people traveling together. These would require the individuals registering together and splitting the cost of the permit. For UTRGV, a carpool permit may help loosen overfilled parking space during peak hours. A brief survey was also recommended to the school to collect more accurate commuting data while purchasing parking permits and this change can assist the university to achieve a significant reduction of scope 3 emission since commuting contributed 62.3% of scope 3 from the study. An example of the survey is presented in Fig 1.

This survey will ask whether they live on or off-campus, which campus they intend to commute to primarily, their estimate of commuting distance, and weekly frequency of commuting as shown in Figure 2. This will allow a more accurate picture of the commuting habits of students and faculty in determining the carbon footprint of commuters to the campuses. This may also prove beneficial in determining possible new bus routes which will help decrease the number of students commuting by car and lower emissions.

4.3.3. Waste and wastewater

Local landfills close to the university campuses were not practicing any renewable energy generation by firing landfill gas in turbines. Thus, no carbon credit was recouped from the solids waste collection from the campus. Recommended to the school was to send organic wastes like food and yard wastes to the local composting facilities, which will lead to carbon emission reduction.

All wastewater was treated by a centralized wastewater treatment facility close to the university, which was mainly using aerobic treatment at the time of the study. Since biogas recovery is not possible with the aerobic treatment, any carbon credit was claimed from the wastewater data.

4.4. Comparison with peer universities

A carbon footprint study by researchers from a South American university (Vasquez et al, 2015) was referred for comparison. This study compared three scopes of campus carbon emissions from six international universities including three South American universities (A to C in Fig. 3), two US universities (E and F in Fig. 3), and one European university (G in Fig. 3).

UTRGV's scope 1 emission was very close to ones from South American schools but much lower than other US and European schools. It is caused by the fact that UTRGV is located in a semi-arid climate area with long warm months, May through September (the average temperature at 32 °C) and average low temperatures above 21 °C. It is very similar to the climate where reference schools in South America (A to C) are located thus stationary fuel usage for heating by UTRGV was not significant throughout the year. Also, lower carbon emission was possible by using natural gas as a major stationary fuel. It is known that the carbon intensity of natural gas is 56 MTCDE/1000 MMBtu, which is 45% lower than other stationary fuels like diesel or coal (USEIA, 2019).

On the other hand, UTRGV's scope 2 emission from electricity consumption is ranked second among seven schools. South Texas's long warm months necessitated high power consumption for cooling and the school's heavy dependence on non-renewable energy sources resulted in greater scope 2 emissions. Low scope 2 in South American universities reflects little cooling equipment supply in the area as stated by the author (Vasquez *et al.*, 2015). Purchase from local renewable energy sources like solar power generators will reduce emissions associated with scope 2.

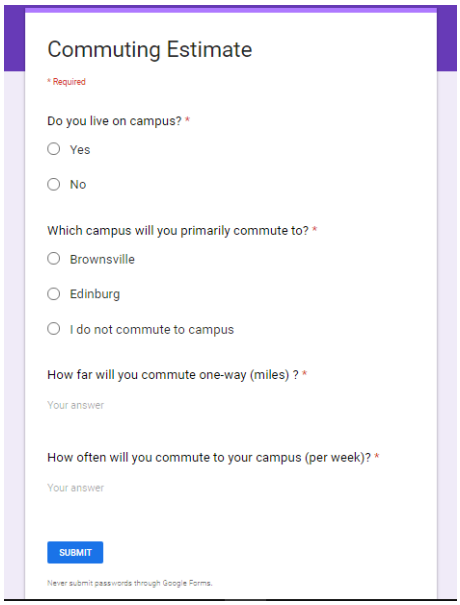

Figure 2. An example of a commuting survey

UTRGV's scope 3 emission was the greatest among seven schools. It is caused by the UTRGV being the only university in the Rio Grande region, South Texas, which results in greater commute distances. Also, there are limited public transportations available in the region so the personal vehicle is the preferred commuting method. Also, it is speculated that the significant cause was the rough commute data collection and analysis. Schools with lower scope 3 emissions were mostly encouraging public transportation and non-fossil fuel based commuting methods like bicycling. The majority of students and faculties in the European University (G) commuted in their car, which caused the scope 3 emission to be greater than other reference schools. Given that most students and faculties in UTRGV used personal vehicles for commute and estimation of commute distance from registered zip code only inadvertently elevated the carbon emission associated with fuel consumption during a commute, greater scope 3 emission was inevitable. Collecting data close to the real commute trend is very important to find the true scope 3 emissions from UTRGV. Also, alternative commuting methods like carpooling and using public transportation should be encouraged among faculties and students in UTRGV to improve scope 3 emission in the future.

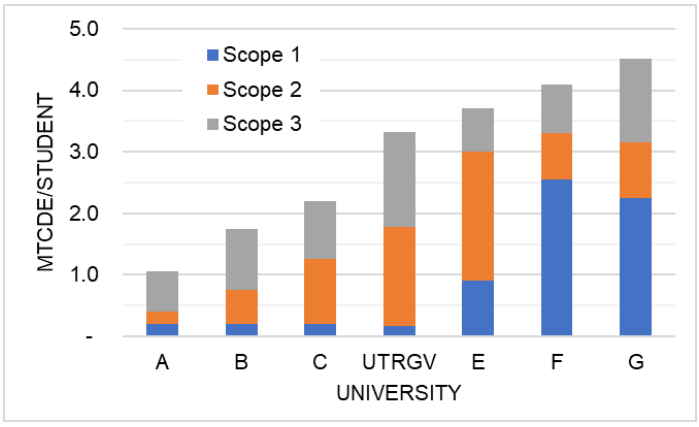

Figure 3. Comparison with peer universities

UTRGV has ample opportunities to expand sustainability efforts. Considering the university's geographic location with near-daily sunshine, making an educational opportunity to engage with photovoltaic panels can be an avenue to lower emissions as well as educate students in the sciences and engineering beyond the lecture hall. As the university continues construction, producing sustainability standards in materials purchasing should be considered additionally to the sustainability of the new building itself. Another suggestion in reducing a sizable contributor to the university's footprint is providing incentives to carpools such as discounted parking permits or convenient locations. Also, UTRGV can utilize separate permits for groups of two or more students/faculty to reduce campus congestion likewise to local air quality improvement.

5. Conclusions

By beginning the effort of collecting data on resource usage and reporting its emissions, UTRGV has laid the framework of tracking its progress in optimizing consumption in a way to promote campus sustainability and campus carbon footprint. Among many suggested improvements, the following is highlighted during the study:

- Purchasing renewable power sources, either wholly or partly, will improve UTRGV's campus carbon portfolio by reducing scope 2 emission.
- A commute survey may help upgrade scope 3 emission data collection. This will enable more realistic commute data, which was not possible during the study discussed herein.
- Alternative commuting strategies such as carpooling, dual car permits, public transportation will reduce scope 3 emission.
- If possible, sending organic waste like food waste to the local compost facility will help reduce campus carbon footprint by allowing UTRGV to collect carbon credit and canceling some scope 3 emissions.

Acknowledgment
A special thanks to members of the Sustainability Office and the Accounting office at UTRGV for their assistance in collecting and reviewing data.

References
[1] B. Potier, "UNH-Sightlines Report: Colleges Reduced Carbon Emissions by 13% per Foot since 2007", Webpage information retrieved in September 2019 from https://scholars.unh.edu/new/4770.
[2] Gordian, "Sightlines", Webpage information retrieved in September 2019 from https://www.sightlines.com/solutions/.
[3] K. T. Kerman, "Reducing Maintenance Costs With Electric Vehicles", NYC Fleet Newsletter, No. 255, 2019.
[4] L. Vasquez, A. Iriarte, M. Almeida, and P. Villalobos, "Evaluation of greenhouse gas emissions and proposals for their reduction at a university campus in Chile", Journal of Cleaner Production, No. 108, 2015, pp 924-930.
[5] N. Chalfoun, "Greening university campus buildings to reduce consumption and emission while fostering hands-on inquiry-based education", Procedia Environmental Sciences, No. 20, 2014, pp. 288-297.
[6] S. Abolarin, A. Gbadegesin, M. Shitta, A. Yussuff, C. Eguma, L. Ehwerhemuepha, and O. Adegbenro, "A collective approach to reducing carbon dioxide emission: A case study of four University of Lagos Halls of residence", Energy and Buildings, No. 61, 2013, pp. 318-322.
[7] T. C. Letete, N. W. Mungwe, M. Guma, and A. Marquard, "Carbon footprint of the University of Cape Town", Journal of Energy in Southern Africa, Vol. 22, No. 2, 2011, pp. 2-12.
[8] The Sustainability Institute at the University of New Hampshire, "SIMAP Home. Retrieved from Sustainability Indicator Management & Analysis Platform", Webpage information retrieved in September 2019 from https://unhsimap.org/.
[9] U.S. Energy Information Administration, "How much carbon dioxide is produced when different fuels are burned?", Webpage information retrieved on February 2020 from https://www.eia.gov/tools/faqs/faq.php?id=73&t=11.
[10] UTRGV Office of Strategic Analysis and Institutional Reporting, "Data and Reports. Retrieved from Office of Strategic Analysis and Institutional Reporting". Webpage information retrieved on September 2019 from https://www.utrgv.edu/sair/data-reports/index.htm.

Corresponding Author Dr. Jongmin Kim is an assistant professor at the civil engineering department, UTRGV. He has been with the school for 5 years. He has published 10 journal papers and presented at more than 30 conferences. He is the journal reviewer for 7 peer-reviewed environmental journals and has reviewed about 150 papers. His current research interest includes campus carbon footprint monitoring, sustainable development, and electrochemical water hardness removal.