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Realizing Carbon Emission in the Engineering College Campus towards Energy Sustainability

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Abstract: Carbon dioxide is the chief element of the greenhouse gases which has a serious implication for global warming and consequent climate change. Carbon footprint is an indicator of impact of our activity on climate change. To assess the impact of various activities of colleges on environment carbon footprint is estimated by considering the energy consumption through electricity, vehicle fuel consumption, human factor and solid waste generation. A portion of carbon dioxide emitted will be absorbed by the trees during their photosynthesis process, so the trees have negative carbon footprint. Thus this project is a research regarding the emission of carbon dioxide in the engineering college premises chosen. In this paper the amount of carbon dioxide emitted were quantified for the last academic year, considering the above mentioned parameters. The paper also describes the suggestive measures to reduce the carbon footprint and also software to determine the same.

Keywords: *Carbon footprint, Greenhouse gases, Emission inventory parameters, Carbon software*

1. Introduction

The Emission of carbon dioxide continues to increase as energy consumptions grow, partly due to the age long human habit of burning and the current technological practices that favor the use of fossil fuels as major sources of energy. The amount of carbon produced by the earth in the atmosphere has been of concern in recent time and the realization of low carbon emission will require an understanding of the source, type and quantity of energy use and the extent of emission from such sources. This involves the measurement and determination of extent of emission from the intensity of use. Generally, sustainability includes focusing on raising awareness to improve the overall image as well as bolstering the environmental prestige by encouraging the participation in the development of the strategies or policies for sustainable development, and also by providing incentives to influence and motivate people and institutions to be more active and focused. The assessment of energy sustainability through the emission of carbon dioxide is a key step for university campus sustainability. Human activity and practices require energy for lighting, cooling and other domestic purposes as well as for movements and manufacturing and to sustain life. However, some sources of energy usually place stress on the environment and result in the emissions of carbon dioxide and other greenhouse gases (GHG). Most carbon emission is as a result of combustion from fossil fuel based energy use. Therefore, the more energy is consumed, the more stress is placed on the environment. This is usually in the form of greenhouse gas emission which impacts negatively on the global environment.

The problem of carbon emission is more pronounced specifically in college campus with large population and large spatial size, whose design requires the use of automobile to travel from one place to another within the campus. Similarly, the teaching and learning service delivery, as well as the residential and administrative activities also involves high energy demand for lighting, cooling, and running appliances, while, the movement of vehicles within the campus consumes high amount of fossil fuel energy, whose consumption also results in the emission of carbon dioxide. Similarly, the electricity consumption in operating machines and transportation fuels of the university campuses, results in high emission of carbon dioxide, having serious implication on environmental quality. Also the products of direct and indirect activities such as classrooms, laboratories, offices and the consumption of food and drinks generate negative environmental impacts. The combine activities of the global campus population constitute significant energy use; hence, universities offer great potential for sustainability globally.

Therefore, focusing on achieving reduction of carbon emission from energy use in the engineering college campuses by encouraging low carbon emission through the involvement of colleges and achieving energy sustainability within the campus by the reduction of carbon dioxide emission may benefit global energy sustainability and remedy the current problems of global warming. The operational approaches to meet sustainability goals in the universities are diverse and the practices are very broad and include improved environmental performances that may not necessarily be equivalent to sustainability. Sustainability is linked with setting

quantitative targets in areas such as energy use, water use, use of land, purchases of product and emissions to air, water and land and achieving sustainability in the university is a process of setting goals to determine the extent of the aspects of the university required to be sustained. Therefore, sustainability in university campus infers adopting intellectually defendable target for meeting the transition to sustainability and then developing the approaches and time scale designed to reach the target. Also, focusing on the assessment procedure of sustainability where quantitative or qualitative value measures of the paradigm are developed for particular situations will assist to meet legitimate sustainability targets especially in the universities and colleges. Hence, each college must determine its goals for itself.

Therefore, the inventory of carbon dioxide from transport and electricity focuses on energy consumption within the campus. By detecting the carbon dioxide emission, the reports are presented in percentages of metric tons of carbon dioxide (Tco2) equivalent towards creating carbon reduction program to achieve more energy sustainable university campus. This will provide an understanding of the pattern and quantity of carbon dioxide emission within the campus, so that the university authority can plan emission reduction based on informed decisions.

2. Objectives

The main objective of this thesis is to understand the amount of carbon dioxide emissions at campus and to suggest suitable solutions to reduce the carbon emissions in the campus. This project was done with the reference of suitable literature surveys and relevant methodologies are also involved in monitoring and analysis. The methodologies proved to be a guideline in understanding the progress of project work and also to identify the specific problems arising during the process. This paper helps to understand the need of carbon footprint analysis at a campus and also the need for an energy sustainable campus.

Carbon footprint is an important parameter, as it is the measure of total amount of carbon dioxide emissions caused by different factors. So by analyzing the carbon footprints at campus, the rate of carbon emissions can be calculated and suitable remedies can be initiated. So the main objective of this paper is,

- To compare the carbon footprints of two engineering colleges by quantifying the carbon emissions in metric tons (colleges chosen: GEC Trissur and Nehru institute of technology Coimbatore).
- To develop software in VB.Net to calculate the carbon footprints effectively at the campus.
- Recommendation for future actions that the colleges can implement to reduce the carbon foot print and control.

3. Scope

We measure the campus carbon emission to help us monitor our impact on the environment. Mainly the emissions are due to the parameters like transportation inside the campus, the electricity consumption, human factors, and solid waste etc.Due to the emissions the energy sustainability of the campus gets reduced and this in turn affects the health of occupants in the campus. So by analyzing the carbon footprint the amount of carbon emissions can be quantified and there by suitable suggestions can be recommended to reduce the same. As the carbon footprint calculator, software is also developed emissions are recorded in often and so the accuracy of analysis increases. After quantifying the amount of emissions suitable actions can be implemented to decrease the emissions and the campus can be made energy sustainable.

4. Carbon footprint

A Carbon footprint is the total set of greenhouse gases caused by an organization, event, product or person through transport, land clearance, production and consumption of food, goods, materials, wood, buildings and services. In a nutshell, the more we buy, the more emissions will be caused on our behalf. It has been used as an environmental indicator to understand and quantify the main emission sources and it constitutes as an effective tool for energy and environment management. It helps us to determine the quantity of emission from different carbon emitting sectors, which in turn is useful for quantifying the impact of human activities on the environment and global climate. Carbon dioxide concentration in the atmosphere has been rising alarmingly in the post industrial revolution era and the current level is about 379 ppm (ppm¼ parts per million) compared to 280 ppm earlier (pre industrialization). The Planning Commission of the Government of India advocates in the12th Five-Year Plan of the country for low carbon growth. The proposed actions will reduce India's emission intensity from 20% to 25% by 2020 with respect to the emissions in 2005. This includes policy interventions to reduce emission intensity through fuel-efficiency standards, green building code and energy efficiency certificates. This necessitates decentralized mitigation strategies to minimize carbon emissions which require sector wise and region wise inventory of GHG emissions.

5. Methodology

Carbon management is of increasing interest to individuals, households, and communities. In order to effectively access and manage their climate impact it is necessary to quantify the carbon footprint. Carbon footprints are a widely accepted method of measuring the impact of human activity on climate change.

Carbon dioxide contributes to global warming by accumulating in our atmosphere like a thick, insulating blanket resulting in rapid climate changes. Fluctuations in global temperature occur naturally and have been reoccurring for millions of years. In the

past, changes in Earth's temperature - cooling and warming - spanned thousands of years each time, allowing the planet and all living creatures to slowly adjust. The difference today is that this temperature change, in this case global warming, is occurring at lightning speed.

By comparing the carbon footprint of two colleges we can establish a baseline for our current use of resources and carbon output will help the college to take tangible action steps to reduce our carbon emissions.

5.1 Proposed Methodology

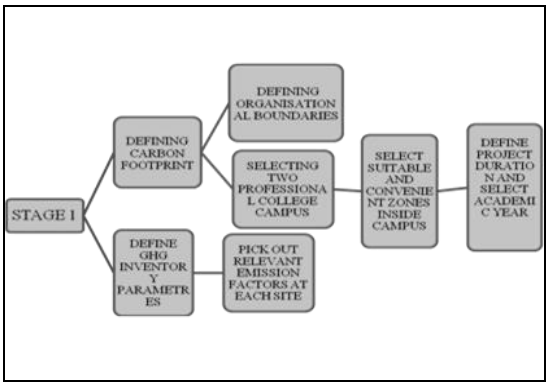

Figure 1.*Flowchart for stage 1*

Table 1.*Parameters Considered*

Emission releasing Activity	Source of Information
Electricity use	Kilowa total kilowatt hours used from elelectricity bill
Human factor	total number of staffs and students
Fuel used in vehicles	litters of fuel used and mileage of vehicle
Solid waste	Amount of waste in Kg
Trees	Area of trees in m^2
Building	Total built-up area in m^2

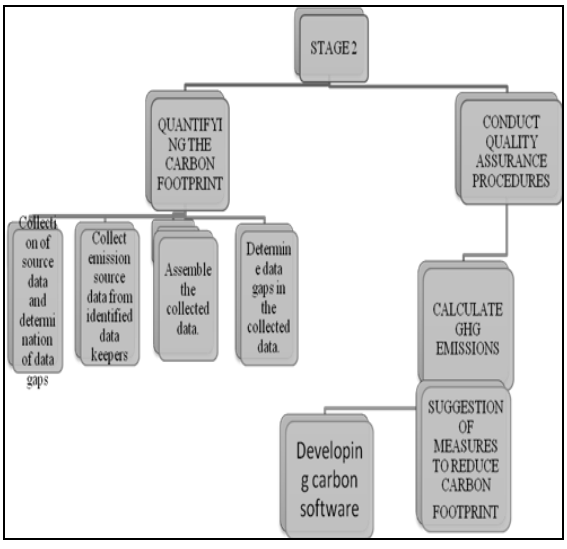

Figure 2*.Flowchart for stage 2*

Table 2.*Emission Factors for Various Parameters*

Item	Kg CO_2
Electricity	0.82 per KWh
Waste disposal	0.8647 per Kg
Concrete work	0.2 Kg/m^2 in a year
Car	2.325 per Liter
Motor bike	2.325 per Liter
Bus	2.73 per Liter

6. Manual method -Life Cycle Assessment (PALCA)

This is a bottom-up method dependent on process data for the emission sources within the study boundary. As its definition usually includes non-carbon Greenhouse Gas emissions and uses CO_2 equivalent as the unit of measurement, Carbon Footprint is very similar to the Global Warming Potential (GWP) indicator in LCA. Thus LCA can be used to estimate the CF of products throughout their life cycle. It is an efficient method to obtain a comprehensive CF for certain products, for which LCA databases have been well established. As a dominant method for product CF assessment, some LCA standards have been developed to standardize data collection and calculation processes, including ISO 14040 and PAS 2050. The standardization makes it possible to compare the CF of similar products, and to provide the foundation for CF labeling.

However, when applying LCA to Carbon Foot printing, one might suffer from a system boundary problem, which is a major difficulty for LCA. Especially for open-loop systems with recycling and reuse processes, designating system boundaries requires practitioners to have profound knowledge in LCA. A systematic truncation error is likely to occur when system boundaries are defined arbitrarily, causing relevant emissions to be ignored. The other limitation is that LCA is not appropriate for estimating CF of larger entities such as municipalities, cities or industrial sectors, because it demands a huge amount of data on the products and intensive work on information processing. Even though estimates can be derived using information available in LCA databases, results will become increasingly patchy as a subset of individual products is assumed to be representative for a larger product group and information from different databases have to be used, which are usually not consistent. So by considering the limitations of life cycle method a software is also developed to determine the carbon footprints inside the campus.

7. Results and findings

- ***Campus details of GEC Trissur***

- Total Area of the College = 3, 03,450 m^2
- Total area of the College considering = 1, 76,780 m^2
- Total built up area = 51,600 m^2

- Tree Coverage Area = 61,974 m^2

- ***Campus details of NIT Coimbatore***

- Total Area of the College = 68796 m^2
- Total area of the College considering = 9120.106 m^2
- Total built up area = 9120.106m^2
- Tree Coverage Area = 59675.8m^2

7.1. Calculation Details

- For the determination of carbon footprints for each campus 6 parameters were considered.
- The amount of carbon emission was calculated for a period of 9 months extending from June 2015 to February 2016.
- Emission from the parameters like electricity, transportation and human factor were calculated for each month from June to February.

- ***CO_2 emission from human breathing***

Carbon dioxide emitted by a person per day is not negligible. It is equivalent to the emission of a car in a 5km stretch. Just for breathing, humans emit per person each day 1000 grams of CO_2, assuming that they eat normally and follow a mean diet of 2800kcal. The population details of each zone include the total number of teaching faculty, non-teaching staff and students is 3240 at GEC and 1536 at NIT. The carbon dioxide emissions will be larger in the Zone having highest population. The emissions are calculated by multiplying the human factor with respective carbon emission factor.

- ***CO_2 emission from electricity***

Collect data on annual electricity bills. Find number of power units (In India, one unit = 1KWh of electricity) consumed in college from the monthly electricity bills issues by State Electricity Board/ Distribution/Collection companies. Take monthly consumed units and then multiply them by 12 (No of months in a year). Electricity consumption includes Lab, administrative block, internet facilities, staff room and class room and pumping of water. The monthly consumption of electricity is multiplied by the emission factor (0.82) will give the corresponding CO_2 emission in kilogram.

- ***CO_2 Emission from Vehicle Fuel Consumption***

- The vehicle details of the campus are collected and equivalent CO_2 emission is calculated.
- Assumed that each vehicle was travelled a distance of 10 Km per day.
- Multiplying the monthly fuel consumption of the vehicle by the corresponding emission factor will give equivalent carbon dioxide emission from each vehicle

- ***CO_2 Emission from Buildings***

Buildings emit considerable amount of carbon dioxide into the atmosphere and add to the Carbon footprint. Continuous emissions are there from buildings. A square meter of brickwork produces 28 kg of carbon dioxide by the time it is delivered to site. That equates to just 0.0001867 tones per square meter a year, over 150 years, carbon emission of concrete work is 0.2 Kg/m^2 in a year. The details of the total built up area of buildings and other structures in the campus are calculated and multiply with 0.2 provides the amount of carbon emission from buildings

- ***CO_2 Emission from Waste Disposal***

- Daily campus waste includes canteen waste, paper waste, plant leaves, laboratory waste etc. There is a biogas plant of capacity 10 m^3 within the campus. Almost all the canteen waste is dumped in the plant itself. Approximately 10 Kg waste is generated daily in a working day and 3 Kg/day in vacation period. Consider 240 days as working periods and 60 days as vacation period.(at GEC)
- Emission factor for waste disposal = 0.8647 per Kg
- CO_2 emission = (240 x 10 x 0.8647) + (60 x 3 x 0.8647) = 2577 Kg CO_2/year
- Therefore total CO_2 emission from waste disposal from the campus for the last academic year = 2577 Kg CO_2/year
- (At NIT) Consider 240 days as working periods and 30 days as vacation period.
- Emission factor for waste disposal = 0.8647 per Kg
- CO_2 emission = (240 x 10 x 0.8647) + (30 x 3 x 0.8647) = 2153 Kg CO_2/year
- Therefore total CO_2 emission from waste disposal from the campus for the last academic year = 2153 Kg CO_2/year.

- ***CO_2 Absorption by Trees***

- Plants absorb carbon dioxide during photosynthesis, using sunlight or artificial light as an energy source to convert CO_2 and water into sugars, cellulose and other carbohydrates and release oxygen. Tree can absorb 12 gm CO_2/m^2/year..
- Total green coverage in the GEC campus = 61974 m^2
- CO_2 absorption by trees in a year = (12 x 10^{-3} x 61974) = 744 kg CO_2/ year
- Total green coverage in the NIT campus = 59675 m^2

Table 3.*Total CO_2 emission from different sources for the last academic year (GEC Campus)*

Sources of CO_2 emission	Total emission in Kg CO_2 e
Electricity consumption	147059
Human breathing	301484

Transportation	45331
Solid waste	2577
Building emission	10,320

***Table 4**.Monthly CO_2 Emission from Different Sources for the Last Academic Year (GEC Trissur)*

Month	CO_2 emission from electricity consumption	CO_2 emission from human breathing	CO_2 emission vehicle fuel consumption	Total CO_2 emission in Kg CO_2 e / year
June	14949	24403	3844	43196
July	16015	40720	4510	61245
August	16080	39820	5491	61391
September	14186	29224	4342	47752
October	17515	44673	6456	68644
November	18130	25010	5800	48940
December	15154	20874	4352	40380
January	17630	41500	5201	64331
February	17400	35260	5335	57995
Total CO_2 emission from these three sources in an Academic year				49384
CO_2 Emission from waste disposal in an Academic year				2577
CO_2 emission from building in an Academic year				10320
CO_2 absorption by tree in a year				744
Total CO_2 emission from the college for the last Academic year				50602

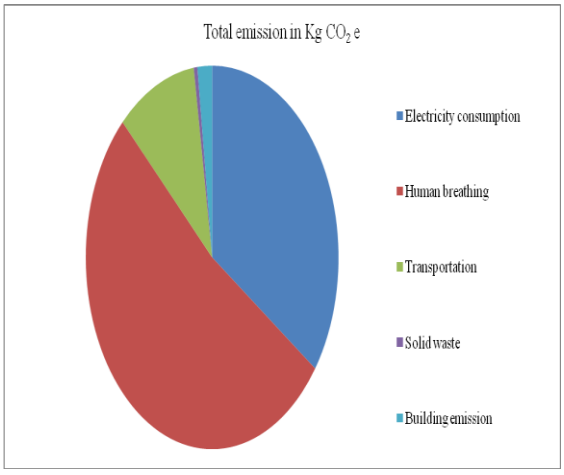

***Figure 3**.Image of pie chart showing carbon emission from all sources (GEC Thrissur)*

***Table 5.**Total CO_2 emission from different sources for the last academic year (NIT Campus)*

Sources of CO_2 emission	Total emission in Kg CO_2 e
Electricity consumption	181937
Human breathing	147062
Transportation	482434
Solid waste	2153
Building emission	1824

***Table 6**.Monthly CO_2 Emission from Different Sources for the Last Academic Year (NIT Coimbatore)*

Month	CO_2 emission from electricity consumption	CO_2 emission from human breathing	CO_2 emission vehicle fuel consumption	Total CO_2 emission in Kg CO_2 e / year
June	17547	10860	26694	55101
July	20414	17997	54378	92789
August	23052	19488	57612	100152
September	21045	19554	65119	105718
October	18177	20602	66214	104993
November	16282	11809	47209	75300
December	15654	12065	47279	74998
January	20528	16368	46543	83439
February	23281	18319	71386	112986
Total CO_2 emission from these three sources in an Academic year				811433
CO_2 Emission from waste disposal in an Academic year				2153
CO_2 emission from building in an Academic year				1824
CO_2 absorption by tree in a year				597
Total CO_2 emission from the college for the last Academic year				814813

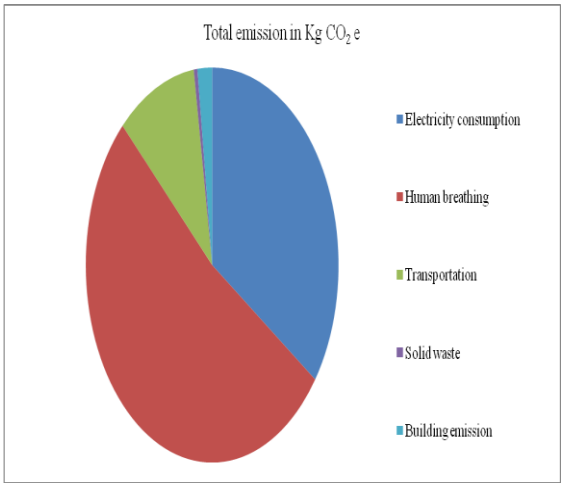

***Figure 4**.Imageof pie chart showing carbon emission from all sources (NIT Coimbatore)*

8. Comparison

- Total carbon footprint of the Government Engineering College for the last Academic year from various sources like electricity consumption, water consumption, human breathing, solid waste disposal, and building and after tree absorption is found to be 506 M tonnes CO_2 e and for NIT campus it is 815 M tonnes.
- The major carbon dioxide emission at GEC is due to human factor and electricity consumption and at NIT the major emission is due to transportation and electricity consumption.

9. Methods to reduce carbon footprint

➢ ***Transportation***

- In an effort to reduce greenhouse gas emissions from student, faculty, and university vehicles, campuses can implement innovative methods to reduce vehicle fuel usage.
- Give Free Bicycles to First-Year Students
- Use energy efficient fuels for transportation, especially in the case of college buses.
- Use vehicles adhering to emission norms.
- Purchase vehicles with competitive mileage & fuel efficiency.
- Encourage use of public transport facilities.
- Carpooling can be encouraged.
- Ensure proper inflation of vehicle tyres.
- Use of Bicycles can be encouraged.
- Encourage walking when it comes to short distances.
- Remove unnecessary weight from vehicles.
- Use unleaded petrol in vehicles.
- Reduce use of petroleum products.

➢ ***Electricity***

- Use electricity effectively.
- Encourage "day lighting" – the use of natural light to illuminate interiors during daylight hours.
- Use the 'OFF' switch, rather than the 'STAND BY' mode.
- Switch off fans & lights when not in use.
- Use LEDs instead of conventional light sources.
- Check for Green Tags before purchasing goods.
- Air Conditioning should be minimally used.
- Keep equipments in power save mode.
- Use solar power.

➢ ***Computer Procurement Policies***

Replace CRT monitors with LCD monitors, which use only about a third to one half the energy of a CRT. The Colleges can adopt guidelines for buying greener electronics, disposing of e-waste and so called "take-back" recycling, which places the burden of e-waste recycling and disposal on the electronics materials.

➢ ***Green Building Design***

- In order to reduce greenhouse gas emissions almost immediately, campuses are investing in building energy efficiency by improving the energy performance of existing and new buildings.
- A "green roof" is a roof of a building that is partially or completely covered with vegetation and soil. Green roofs provide energy savings (insulation for both heating and cooling), water runoff reduction, increased roof lifespan, aesthetic improvements, and other environmental benefits.

➢ ***Solid waste***

- Avoid wasting paper.
- Avoid burning of paper waste.
- Recycle waste if possible.
- Reuse resources whenever possible.
- Adopt proper waste management techniques.

➢ ***Using Native Plants in Campus Landscaping***

In order to combat invasive species threats and to maintain adaptive plants, colleges can establish a policy of using native species in campus landscaping that require minimal water and fertilizers

10. Carbon Software: Carbon footprint calculator

- Carbon software is a tool specifically designed to determine the amount of carbon emissions inside the campus
- Carbon software is a program which is developed in VB.NET.
- **Visual Basic .NET (VB.NET)** is a multi-paradigm programming language, implemented on the .NET Framework. Microsoft launched VB.NET in 2002 as the successor to its original Visual Basic language. Although the ".NET" portion was dropped in 2005, this article uses "Visual Basic [.NET]" to refer to all Visual Basic languages releases since 2002, in order to distinguish between them and the classic Visual Basic.
- Here in this project VB .NET is performing as a prominent tool in which a program is created known as Carbon software, which is regarded as an efficient mitigating tool for analyzing the carbon emission inside the campus.

Figure 5*.Image of carbon software*

11. Conclusion

- An investigation was carried out to quantify the total carbon footprint of two engineering colleges and compared the carbon emission from two colleges.
- By quantifying the carbon footprint it helps to identify the major carbon emitting sources and control measures also suggested so that future carbon emission can be significantly reduced.
- It is important that there should be a significant reduction in GHGs emissions to avoid significant climate change. Forestation is a great step for carbon emission reduction.

- Total carbon footprint of the Government Engineering College for the last Academic year from various sources like electricity consumption, water consumption, human breathing, solid waste disposal, and building and after tree absorption is found to be 506 M tonnes CO_2 e and for NIT campus it is 815 M tonnes e.
- The major carbon dioxide emission at GEC is due to human factor and electricity consumption and at NIT the major emission is due to transportation and electricity consumption.

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