# Carbon Footprint of an Academic Building - A Case Study

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***Abstract-*** **Carbon dioxide ($CO_2$) is a major constituent of green house gases responsible for climate change. Since industrial age the concentration of CO2 in the earth atmosphere has been increased considerable. The sources of CO2 in the atompshere are both natural and manmade. However, the electricity through various sources is one of the major contributors of $CO_2$ in the atmosphere. Energy usage can be minimized largely by changing the lifestyle by awareness on energy conservation. Keeping this mind, in this paper an attempt has been made to quantify the carbon footprint for energy usage of the academic block of BRCM college of Engineering and Technology, Bahal. In order to determine the carbon foot print data on daily energy consumption from various sources including electricity generation from solar panels, diesel generators and electricity comes from grids of Haryana state electricity board, liquid fossil fuels consumed by transportation vehicles. It was assumed that electricity receiving from grid solely comes from thermal power plants. We have estimated the emissions of $CO_2$ for the consumption of liquid fossil fuels and electricity from various sources for a period of one year. The results show that carbon dioxide emissions in this one year are estimated to be 599.9 metric ton. This study will in understand the $CO_2$ foot print and and ones contribution towards global warming and climate change. It is expected that the authority and individual will understand their responsibility and will work jointly by adopting the recommendation suggested in this study to reduce the consumption of energy as a part of their environmental stewardship.**

***Keywords—*** *Green house gas, carbon foot print, energy usage, $CO_2$ Emissions*

## I. INTRODUCTION

The increase of greenhouse gases (GHG) emissions is an important and most concerned issue. Human activities are currently based on high consumption of fuels, and are actually the major cause of GHG emissions, which can undoubtedly be related with climatic changes [1]. There are six greenhouse gasses (GHGs) with their respective radiative forcing and global warming potential (GWP) [2]. However, carbon dioxide (CO2) emissions are the most important of the GHGs that are increasing in atmospheric concentration because of human activities [3]. Transportation, industrial and electricity production (with fossil fuels combustion) are the main sectors identified to contribute to the emission of $CO_2$ in BRCM. $CO_2$ emissions considered in this study are from the fossil liquid fuels consumption needed for transportation and solar power plant for electricity production.

Figure 1-1 shows the average global temperature deviation from the mean, the $CO_2$ concentration in the atmosphere, and annual carbon production as a function of time over the last 250 years. There are still questions about its exact magnitude, but all the available evidence points to a rise in the average global temperature as the $CO_2$ concentration increases. These data indicate that the burning of fossil fuels, coupled with the destruction of vast forests, have led to a rise in $CO_2$ concentration approximately 25% above the level that existed before humans began interfering with the Earth's natural heat balance [4].

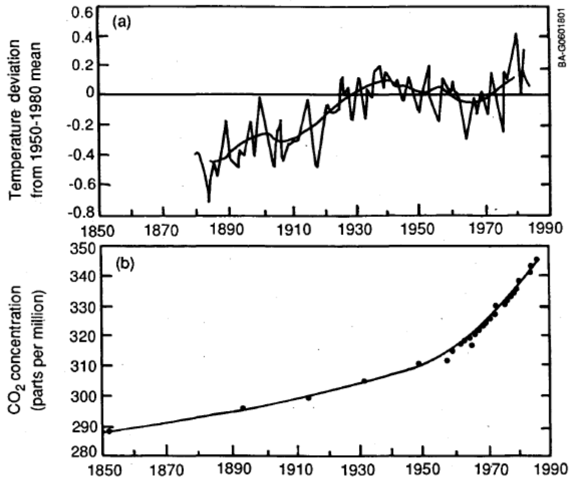
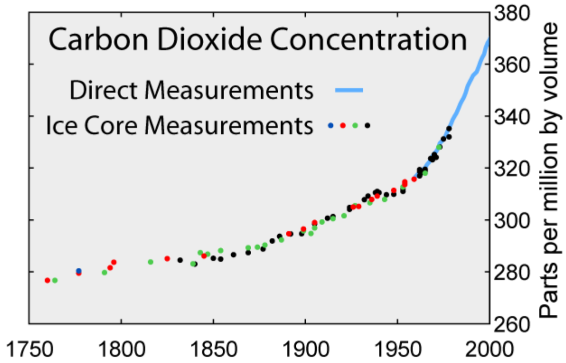



Figure 1: Historical changes in global temperature and carbon dioxide concentration




Graph (c)

Figure 2: Global $CO_2$ concentration direct measurement and Ice core measurement

Figure 1 shows the annual mean (spiky curve) and the 5-year mean (smooth curve} global temperature. Graph (b) shows the atmospheric $CO_2$ concentration for past 250 years (annual mean spiky curve), Graph (c) shows the atmospheric $CO_2$

content come from analysis of air trapped in bubbles of glacial ice from around the world for the past 250 years) [5]. According to Bath and Feucht (1990), current estimates of global $CO_2$ emissions from fossil fuel use (expressed as giga tons of carbon) are about 5.1 GT per year. Reductions of biologically fixed carbon, mostly from deforestation, add about 1 to 1.5 GT of carbon to the atmospheric input. Of this annual total of about 6.5 GT of carbon, roughly 3 to 3.5 GT are removed from the atmosphere by the oceans, leaving a net input of about 3 GT of carbon per year. This agrees with the observed rate of increase in atmospheric $CO_2$ (0.5% per year) and suggests with some confidence that a 50% reduction from current emission levels would bring the atmospheric carbon cycle back into balance, stabilizing the $CO_2$ concentration in the atmosphere (Bath and Feucht 1990). However, if we continue burning fossil fuels at current rates, the buildup of $CO_2$ in the atmosphere will trap increasing amounts of infrared radiation emitted by the Earth and result in a warming of the Earth's surface. For the past ten years (2005 - 2014), the average annual rate of increase is atmospheric $CO_2$ concentration is 2.11 parts per million (ppm). This rate of increase is more than double the increase in the 1960s as shown in below table 1. [5]

TABLE I: DECADAL CHANGE IN $CO_2$ AT GLOBAL SCALE

| Decade | Total Increases | Average Annual Rates of Increase |
|---|---|---|
| 2005-2014 | 21.06 ppm | 2.11 ppm per year |
| 1995-2004 | 18.67 ppm | 1.87 ppm per year |
| 1985-1994 | 14.24 ppm | 1.42 ppm per year |
| 1975-1984 | 14.24 ppm | 1.44 ppm per year |
| 1965-1974 | 10.56 ppm | 1.06 ppm per year |
| 1960-1964 (5years Only) | 3.65 ppm | 0.73 ppm per year |

## II. $CO_2$ EMISSION

### A. *From thermal Power Plants*

The combustion process of the pulverized coal in the boiler is a complicated non-linear phenomenon. The pollutants emitted from thermal power plants depend largely upon the characteristics of the fuel burned, temperature of the furnace, actual air used, and any additional devices to control the emissions. At present, the control devices used in thermal power plants in India is electrostatic precipitator (ESP) to control the emission of fly ash (SPM). Some new plants use low $NO_X$ burners for high temperature (> 1500 K) combustion technologies and dry/wet $SO_2$ scrubber, if chimney height is less than 275 meters. Mass emission factors for $CO_2$, $SO_2$, and nitric oxide (NO) are computed based on the input data, such as chemical composition of the coal used at the power plants and the actual air used during combustion. These calculations are based on theoretical ideals and do not take account for the control devices. Indian coal generally has low sulfur contents. The operative combustion temperature is assumed to be 1200 K. From the elemental analysis of the coal, the percentage of carbon, hydrogen, nitrogen, oxygen, ash, and moisture in the coal is known. Let C be the mass of the carbon then mass of $CO_2$ calculated by mass balance as [6]

$$CO_2 = C*44/12$$

### B. *From Electric Solar photovoltaic Panel*

The carbon footprint of a solar photovoltaic (PV) panel – the average level of greenhouse gas emissions it is responsible for over its lifetime – is about 72 grams of carbon dioxide-equivalent per kilowatt-hour of electricity generated ($gCO_2e/kWh$). Generating electricity using solar PV panels does not produce greenhouse gases directly. But emissions are associated with other parts of the panels' life cycle: manufacturing and transporting them. The main components of solar PV panels are made from crystalline silicon. Manufacturing these components is an energy-intensive process which accounts for 60% of the total energy used to make solar panels. The exact carbon footprint of any particular solar panel depends on many factors, including the source of the materials, the distance they have to be transported and the energy source used by the manufacturing plants. For example, the $CO_2$ produce by China made solar PV plate is 68g/kWh and Europe made solar PV plate is 32g/kWh [7]

### C. *From fossil fuels*

(i) *Diesel:* 1 liter of diesel weighs 835 grammes. Diesel consist for 86,2% of carbon, or 720 grammes of carbon per liter diesel. In order to combust this carbon to $CO_2$, 1920 grammes of oxygen is needed. The sum is then 720 + 1920 = 2640 grammes of $CO_2$/liter diesel. An average consumption of 5 liters/100 km then corresponds to 5L x 2640 g/L/ 100 (per km) = 132 g $CO_2$/km.

(ii) *Petrol:* 1 liter of petrol weighs 750 grammes. Petrol consists for 87% of carbon, or 652 grammes of carbon per liter of petrol. In order to combust this carbon to $CO_2$, 1740 grammes of oxygen is needed. The sum is then 652 + 1740 = 2392 grammes of $CO_2$/liter of petrol. An average consumption of 5 liters/100 km then corresponds to 5 l x 2392 g/l / 100 (per km) = 120 g $CO_2$/km [8].

## III. $CO_2$ FOOTPRINT – CASE STUDY

The academic block of BRCM CET, Bahal was chosen for this case study.

(i) *From power taken from Thermal Power Plant* as per the data collected from last one year. The power taken from thermal power plant are 453442 kWh. So the $CO_2$ footprint is obtain as:
$CO_2$ produce to generate 1 kWh electricity is 960gm
Thus $CO_2$ produce to generate 453442kWh electricity = 453442*960 = 435304320gm

(ii) *From power generation from solar plates* as per the data collected from last one year. The power generation from solar plant installed inside the campus is 122745kWh. So $CO_2$ footprint is obtained as:
$CO_2$ produced to generate 1 kWh electricity is 32gm
Thus $CO_2$ produce to generate 122745kWh electricity = 122745*32 = 3927840gm

(iii) *From the power generation from diesel generator* as per the data collected from the last one year. The power

generation from 8497.63 liter diesel is 64376kWh. So $CO_2$ footprint is obtained as:
$CO_2$ produced to generate 1 kWh electricity required 0.132 liter diesel = 348.5gm
Thus $CO_2$ footprint produce to generate 64376kWh electricity is 64376*348.5 = 22435036gm

(iv) From the transportation using diesel as per the fuel consumption collected from the last one year. The consumption of diesel is 37211 litter by different vehicles is obtained as:
$CO_2$ production from 1 litter of diesel is = 2640gm.
Thus $CO_2$ footprint is 37211*2640 = 98237040gm

From this case study it is observed that the $CO_2$ footprint of academic building of BRCM CET, Bahal BRCM is 559.9 metric ton/yr during one year (Sep, 2014 – Aug, 2015) lifetime for producing power from a solar photovoltaic plant, diesel generator, taking power from thermal power plant and the transportation by diesel vehicles. Most of the carbon footprints summarized in this study are based on data for existing processes and technologies; these data will change over time and it would reduce the footprints of the academic building by use energy efficient technology in future. Footprints would also be reduced by improved operating performance, which are likely as technologies develop. The method of life cycle assessment can be used to identify these trends. The general need for location-specific and up-to-date analysis suggests that further studies for the BRCM Campus would improve the evidence base for policy makers.
There are many other impacts of electricity generation beyond the emission of greenhouse gases, such as the production of particulates or requirements for water, and can be combined with other techniques from the physical sciences and from economics to provide more comprehensive assessments.

## IV. FUTURE SCOPE

The electricity consumption of CFLs and LED lamps is low. So the existing fluorescent tube can be replaced by CFLs or LEDs which reduce the power consumption as well as the carbon footprints. $CO_2$ footprint can be reduced by using the following methods in future:

- Increase the end-use efficiency of fuel use by conservation and improved energy conversion.
- Replace fossil fuels with renewable energy sources such complete dependency in solar power.
- Eliminating burning and instituting accelerated reforestation would reduce emissions and absorb atmospheric CO2 as the trees grow and store carbon in their biomass. At present, however, it is estimated that only one tree is planted for every 11 or 12 trees cut down.
- Shift from coal and fossil fuel to natural gas. The combustion of natural gas produces about 40% to 50% less carbon dioxide per unit energy delivered than the combustion of coal.
- Replacement of all type of light with LED bulbs
- Replacement of CFT monitors with LCD monitors etc.
- Regular Energy auditing of the institute and creating awareness among the staff for smart usage to reduce energy wastage.

## V. REFERENCES

[1] J. Gomes, J. Nascimento and H. Rodrigues, "Estimating Local Greenhouse Gas Emissions—A Case Study on a Portuguese Municipality," International Journal of Green- house Gas Control, Vol. 2, No. 1, 2008, pp. 130-135. http://dx.doi.org/10.1016/S1750-5836(07)00098-9
[2] IPCC, "Climate Change 2007: The Physical Science Ba- sis," Cambridge University Press, Cambridge, 2013.
[3] N. S. M. Safaii, Z. Z. Noor, H. Hashim, Z. Ujang and J. Talib, "Projection of CO2 Emissions in Malaysia," Envi- ronmental Progress and Sustainable Energy, Vol. 30, No. 4, 2011, pp. 658-665. http://dx.doi.org/10.1002/ep.10512
[4] F. Kreith, P.Norton and D. Brown, "C02 Emissions from Coal-Fired and Solar Electric Power Plants", SERI/TP-260-3772, UC Category: 233, DE90000337, may 1990. http://co2now.org/current-co2/co2-now/annual-co2.html
[5] Moti L. Mittal, Chhemendra Sharma and Richa Singh, " Estimates of Emissions from Coal Fired Thermal Power Plants in India",
[6] *www.epa.gov/ttnchie1/conference/ei20/session5/mmittal.pdf*
[7] http://www.anl.gov/articles/solar-panel-manufacturing-greener-europe-china-study-says.
[8] http://www.sunearthtools.com/tools/CO2-emissions-calculator.php
[9] House of Parliament, Parliament office of Science & Technology, "POSTNOTE UPDATE", number 383, june 2011.