A model for Low Carbon Campus in Kerala

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I. INTRODUCTION

At present, it is found that the world temperature is reaching a level that has not been seen in thousands of years. The nations were generally worried about climate change impacts and global warming and they started some regulation and direction on this issue. So International discussions have been focused on how the world community must reduce carbon emissions 60% by the year 2050 and the most prominent step in the direction of low carbon power was signed in 1997 under KYOTO PROTOCOL. A low-carbon campus or low-fossil-fuel economy is a concept that refers to an economy which has a minimal output of greenhouse gas (GHG) emissions (in particular, carbon dioxide) into the biosphere. The over-concentration of green house gases is producing global warming, which affects climate in the long term, with negative impacts on humanity in the foreseeable future. In a LCS, the society will adopt a lifestyle that makes more use of energy efficient devices and renewable energy technologies in the field of transportation, electricity, solid & liquid waste management. So this project tends to estimate the amount of carbon emissions produced in College of Engineering, Trivandrum Campus and then bringing solutions to reduce its emission in the coming years and making it as a low carbon campus.

II. SOURCES OF CARBON EMISSION IN THE CAMPUS

The main sources of carbon emissions in the campus are due to the following components

1. Electricity
2. Transportation
3. Human release during exhalation
4. Solid waste by open burning
5. Liquid waste or grey water

A. Consumption of electricity in the college campus

In the college campus, there are mainly two connections for electricity.11 KV high tension and low tension for ladies hostel. The total electricity produced in the year 2012- 2013 is derived from KSEB [Kerala State Electricity Board] bills. Carbon emission in the Consumption stage and Transmission and distribution stage is considered for the estimation. Carbon emission in T& D stage is 20% of emission in the Consumption stage. So the electricity which is 20% more must be produced considering this T&D loss.

[**Procedure followed is from CO2 Baseline Database for the Indian Power Sector guidelines , Version 6, March 2011 , Central Electricity Board**]

TABLE 1: CONSUMPTION OF ELECTRICITY IN THE COLLEGE CAMPUS

Month [2012-2013]	**Consumption (KWh)**	
	College & MH	***Ladies hostel***
August	1,67,045	12,204
September	1,64,038	11,572
October	1,68,773	11,438
November	1,65,612	10,620
December	1,72,751	10,708
January	1,72,492	10,278
February	1,72,612	10,485
March	1,73,483	10,550
April	1,74,842	10,883
May	1,76,328	11,148
June	1,72,966	11,241
July	1,72,374	11,324
Total	20,53,316	1,32,451
Total electricity consumed by the campus = **21,85,767 KWh**		

SOURCE : KSEB BILLS 2012-2013

Along with the production of one Mega Watt hour electricity production, 0.75 tonnes of carbon is emitted as per

Central Electricity Authority for calculating the CO2 emission baseline.

That is,

1 KWh = 1Unit

1000 KWh = 1 MWh

Thus, total electricity consumed in the campus

=21,85,767KWh (2185 MWh)

Carbon emission during the consumption stage

= 2185 MWh X 0.75

= 1639.18 tonnes

Carbon emission in the transmission & distribution stage (Carbon emission in T& D stage is 20% of emission in the Consumption stage)

= 327.83 tonnes

So, total amount of carbon produced due to the electricity usage in CET campus = 1967.01 tonnes

B. Carbon emission by Transportation

Emissions from the transport sector depend mainly on type of transport and fuel apart from type of combustion engine, emission mitigation techniques, maintenance procedures and vehicle age. The major pollutant emitted from transport are Carbon dioxide (CO2), Methane (CH4), Carbon monoxide (CO), Nitrogen oxides (NOx), Nitrous oxide (N2O), Sulphur dioxide (SO2), Non-methane volatile organic compounds (NMVOC), Particulate matter (PM) and Hydrocarbon (HC). These all pollutants are converted in terms of Carbon equivalent for estimating the amount of carbon.

TABLE 2 : LIST OF VEHICLES IN THE CAMPUS

List of vehicles in the campus	Number of vehicles	Distance travelled per day in km (to & fro)
Bus	8	56
Four wheelers Cars Multi utility vehicles	 106 196	 20 20
Three wheelers	10	8
Two wheelers	467	22

SOURCE : SURVEY CONDUCTED IN CET

TABLE 3 : EMISSION FACTORS FOR ROAD VEHICLES AS PER INDIAN INSTITUTE OF PETROLEUM AND AUTOMOTIVE RESEARCH ASSOCIATION OF INDIA

	Bus	Omni buses	Two wheelers	Light motor vehicles (passenger)	Cars and jeeps	Others[a]
CO_2	515.2	515.2	26.6	60.3	223.6	343.87
CO	3.6	3.6	2.2	5.1	1.98	3.86
NO_x	12	12	0.19	1.28	0.2	3.89
CH_4	0.09	0.09	0.18	0.18	0.17	0.11
SO_2	1.42	1.42	0.013	0.029	0.053[b]	1.94
PM	0.56	0.56	0.05	0.2	0.03	0.24
HC	0.87	0.87	1.42	0.14	0.25	0.54

Carbon emission is calculated using the following procedure

Formula = No of each type of vehicles x emission factors (based on age, type of vehicle) x Avg. distance travelled by each vehicle in an year

TABLE 4 : CARBON EMISSION BY EACH TYPE OF VEHICLES IN THE CAMPUS

Type of vehicles	Carbon emissions (tonnes)
Two wheelers	309
Cars	374
Multi utility vehicles	316
Bus	606
Three wheelers	29
Total amount of carbon emitted	**1634 tonnes**

Total amount of carbon produced by Transportation in CET campus per year = 1634 tonnes

[Procedure followed is from Emissions from India's transport sector: Statewise synthesis, Indian Institute of Petroleum and Automotive research association of India]

C. Human Release of Carbon

16.5 kg of air is the inhalation rate of a normal person. Among this, 65% to 70% of CO2 are releasing back. Out of this ,45% of CO2 is taken as the average based on the time spend in the college ,considering day scholars and hostellers.

TABLE 5 : HUMAN RESOURCES IN THE CAMPUS

Human resources	Number
Day scholars	2645
Hostellers (MH + NH)	815
Teaching staffs	289
Non teaching staffs	135
Administrating staff and office	90
Hostel office	30
Total inmates in the campus	4814

SOURCE: CET COLLEGE OFFICE RECORDS

Procedure

Population in the campus x 16.5 (total amount of air inhaled) x average amount of air releasing back as carbon dioxide

= 4814 x 16.5 x 0.45

= 43 tonnes

Thus ,

The amount of carbon produced due to human exhalation in CET campus per year = 15,480 tonnes

D. (iv)Solid waste generation

Solid waste disposal sites are used to treat or dispose of solid wastes and include landfills. Organic matter contained in the waste material at solid waste disposal sites can undergo biological transformation to produce CO2 under aerobic conditions and a mixture of CH4 and CO2 under anaerobic conditions. At the same time burning of solid waste produce CH_4 and CO_2.

As per Central pollution control board,

Per capita solid waste generation for an institute

= 0.0728kg/capita/day

No of inmates in the campus = 4814

Per capita solid waste generation = 4814 x 0.0728

=350.45kg/day

Food and paper waste are the prominent waste produced in CET. The carbon emission factor for landfill gas produced due to the open burning are 0.002989 tonnes /kg.

The amount of carbon produced due to solid waste generation per year in CET = 379.6 tonnes

(*v)Liquid waste generation*

Waste water is another source of producing methane and Carbondioxide.

Liquid waste generated is taken as taken as 75% of water demand. Water demand for hostellers = 160 l/h/d

Liquid waste generated by hostellers = 75 x 160 l/h//d

= 120 l/h/d

Water demand for day scholars and staff

= 45 l/h/d

Liquid waste generated by day scholars and other staff

= 33 l/h/d

Total waste generated = (120x815) + (33.75x [2645+514])

= 204416.25 l/d

Emission factor for liquid waste for institutions are

= 0.003124 kg

The amount of carbon produced due to liquid waste generation per year in CET = 232.87 tonnes

III. CARBON SEQUESTRATION

Although CET emits 1967.01 tonnes of carbon due to electricity, 1634 tonnes of carbon due to transportation, 379.6 tonnes of carbon due to solid waste incineration & landfill, 232.87 tonnes of carbon due to liquid waste generation , 15,480 tonnes due to human exhalation the amount of carbon produced here can be stored in the campus itself by sequestration. Trees remove carbon dioxide from the atmosphere through the natural process of photosynthesis and store the carbon (C) in their leaves, branches, stems, bark and roots.

TABLE 6 : DETAILS OF THE TREES IN THE CAMPUS

Name of the trees	No: of the trees	Amount of carbon sequestered
Mast tree	57	10,403
Ayani	7	8,996
Australian wattle	750	5,775
Teak	30	4,392
Mahagony	140	4140
Tamarind	70	3,992
Mango	68	1,323
Cashew	67	1,299.8
Devils tree	10	811
Mysore gum	21	582.12
Copper pod	73	277
Matti	11	105.227
Raindeer	5	126.30
Bamboo	7	98
Beef wood	51	96.9
Kindal	4	65.70
Rose wood	2	51.40
Neem	9	45.62
Gulmohar	17	43.80
Indian laburnum	14	43.18
Coconut	49	39.74
Foundain tree	20	26.90
Kino tree	9	21.902
Indian beech	3	13.68
Araucaria	5	12.67
Glyricidia	13	12.14

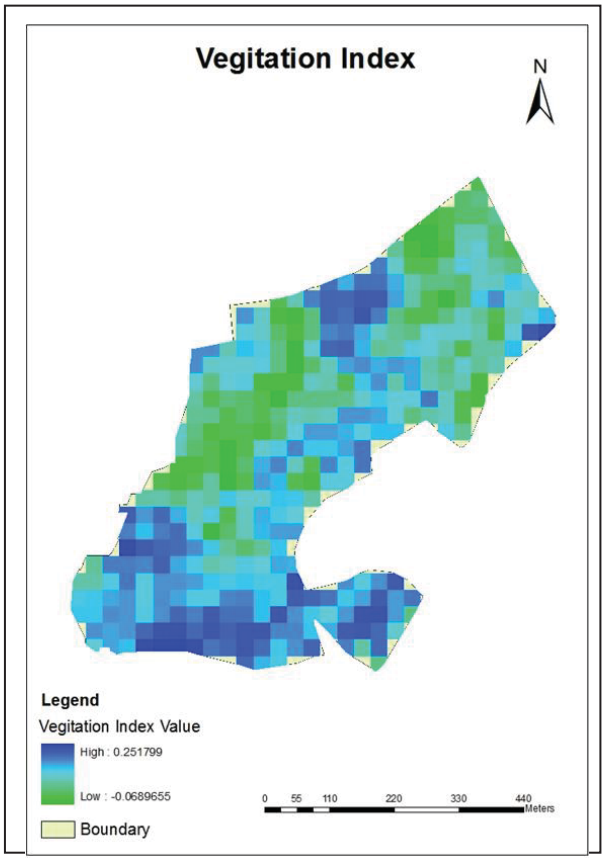
Guava	13	11.86
Oil palm	2	8.11
Jack tree	19	5.54
Maddi	6	5.47
Red sanders	4	5
Cinnamon	2	4.04
Subabul	4	3.65
Kumbil	2	2.86
Sandal	8	1.460
Custard apple	2	1.277
Purijat	2	1.216
Bach	1	0.73
Bilimbe	1	0.456
Yellow alder	5	0.152

SOURCE : "FRIENDS OF TREES", A SURVEY OF TREES IN THE CET CAMPUS DONE IN THE YEAR 2002

Procedure

Formula = Stem Volume x Biomass Conversion Factor x Density of wood(soft wood or hard wood) x Carbon Fraction(Biomass to carbon equivalent) x Carbon to CO2 Fraction. Where, Stem volume = $(\pi/4)\ d^2$, Biomass Conversion factor for softwood = 1.12 and for hardwood = 1.33, Specific gravity (density) for softwood = 0.463and for hardwood = 0.569. Carbon fraction (biomass to carbon equivalent) for softwood and hardwood = 0.5,Carbon to Carbon dioxide fraction = 3.67

IV. GREEN COVERS OF CET USING GIS



The dark blue colour shows place where high vegetative index in the campus, whereas green colour represents places in CET campus other than vegetative cover .That is it may consist of buildings, open places,playgroundsetc. Light blue indicates place where low vegetative index. From this it is possible to find out how much of the pollutants or carbon can be absorbed by the vegetation. Approximately about 60% of the area of campus are covered by vegetation CET campus situates in 45 hectares, among this 26 hectares are covered with vegetation.

V. PRESENT CARBON SCENARIO

Total amount of carbon produced in CET per year
= 19,693.68 tonnes

Total amount of carbon sequestered by all trees in the campus = 42,832.67 tonnes

So, the net carbon pollution in CET campus is negative.That means there is no carbon pollution in the campus

VI. MITIGATION OPTIONS

Following are the mitigation options to reduce carbon content in the campus.These options can be adopted by other campuses in Keralaalso for making the campus"low carbon". The over-concentration of green house gases is producing global warming, which affects climate in the long term, with negative impacts on humanity in the foreseeable future. So inorder to reduce this, like FAR (floor area ratio) , it is better introducing another standard GCR which is called Green Carbon Ratio to make " Carbon negative campus" or "Neutral carbon campus in Kerala"

This can be done in three ways

1. Reducing carbon content in the campus
2. Increasing sequestration of trees by plantations
3. Both reducing carbon and increasing plantations

VII. ELECTRICITY

1) Installing Sensor Meters in each Department :- It helps to reduce energy consumption by switching off the devices automatically so that consumers can save money on their energy bills and reduce emissions
2) Offer rewards and incentives to individual batches or departments for reduced energy consumption
3) Focus on efficiency measure systems, including variable air volume fan systems and heat recovery
4) Incorporate daylight & passive solar design elements to reduce energy consumption

5) Energy efficient lighting and appliances should be put in place to make better use of the energy generated by the solar panels.
6) Develop a device which shows the carbon reading and install it in each departments (like smart meters showing the electricity reading)

VIII. TRANSPORTATION

1) Increase on-campus housing to eliminate student commutes, and to encourage more students, faculty, and staff to live within walking distance of the campus.
2) Attract the staffs and students to use mass transportation by increase in number of college bus and vanpool options for faculty with AC
3) Explore the use of battery operated buses charged using solar energy
4) Use of CNG as an alternative fuel
5) Presently all the buses are returned to CET for parking . The existing dead kilometer per route can be reduced if it Parks in other Govt .Institutions (eg : Barton hill)

IX. OTHER OPTIONS

1) Commit to landscape practices that produce biomass and eliminate the need for grass cutting.
2) Conduct consumer awareness programs to save energy in the Campus
3) Incorporate green standards in all contracts for services and goods
4) Institute annual or semester-based energy competitions among academic buildings to promote efficiency and to encourage students to conserve energy and water
5) Develop campaigns to remind students and employees to power down over breaks
6) Create a campus website to promote energy conservation, recycling, and other environmental initiatives and priorities
7) Develop an information network of students, faculty, and staff from every office and department on campus to help spread the word about programs, policies, and incentives
8) Create campus energy policies and implement efficient operational measures

X. PROMOTE SOIL SEQUESTRATION

1) The goal of soil sequestration is to use the crop and its relation to the carbon cycle to permanently sequester carbon within the soil
2) Having the ability to store 1,500 giga tonnes of organic carbon
3)

XI. SOLAR PANELS

1) As per the guidelines of Solar Rooftop Power Plants scheme for 2012-13 by Agency for Non conventional Energy and Rural Technology (ANERT),
2) Minimum 15 square meter shade free area is required for installing 1 Kw power Solar panel
3) For generating 1 kW power the cost of solar power system = Rs 2.5 lakhs
4) The battery capacity is 5400Wh if the solar PV system is used mainly during the daytime

So CET requires 118200 m^2 roof top area for 6,623 KWh(consumption per day)

1) Number of panels needed = 7880 panels
2) Cost of installing panels to generate 6,623kwh power =2365 lakhs
3) Out of this 30 % subsidies are available from central government i.e. Rs709 lakhs

References

[1] Department of Energy and Climate Change and the Department for Environment, Food and Rural Affairs, 2011 'Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting' ,version 1

[2] Guidelines for Measuring and Managing CO2 ,2011,'Emission from Freight Transport Operations', issue 1

[3] US Environmental protection agency,' Greenhouse Gas Emissions from a Typical Passenger Vehicle', 2011,Office of Transportation and Air Quality

[4] U.S. Environmental Protection Agency,2011,'Light-Duty Automotive Technology,Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2011', Office of Transportation and Air Quality