GREEN AUDIT REPORT

K. S. M. D. B College

SASTHAMCOTTA

2021

OTTOTRACTIONS
Energy-Engineering-Environment

DNRA 170, Valiyavila, Thirumala P.O, Trivandrum
Ph:+919447068747, 9447621674,
email:aea@ottotractions.com, otenergy@gmail.com
www.ottotractions.comns.com

Executed by

OTTOTRACTIONS
Energy-Engineering-Environment

GREEN AUDIT REPORT

K. S. M. D. B COLLEGE

SASTHAMCOTTA

OTTOTRACTIONS
Energy-Engineering-Environment

Green Audit Report

K.S.M.D.B College, Sasthamcotta

Report No: EA 840

2021-October

About OTTOTRACTIONS

OTTOTRACTIONS established in 2005, is an organization with proven track record and knowledge in the field of energy, engineering, and environmental services. They are the first Accredited Energy Auditor from Kerala for conducting Mandatory Energy Audits in Designated Consumers as per Energy Conservation Act-2001. Government of Kerala recognized and appreciated **OTTOTRACTIONS** by presenting its prestigious **"The Kerala State Energy Conservation Award 2009"** for the best performance as an Energy Auditor. Ottotractions is an **ISO 9001-2015 and ISO 14001-2015** Certified organisation, which ensures the quality of its services.

Acknowledgment

We were privileged to work together with the administration and staff of **K.S.M D.B College, Sasthamcotta** for their timely help extended to complete the audit and bringing out this report.

We thank the management of K.S.M.D.B College for entrusting Ottotractions to conduct the audits in all its mentee institutes as part of its Paramarsh Scheme.

With gratitude, we acknowledge the diligent effort and commitments of all those who have helped to bring out this report.

We also take this opportunity to thank the bona-fide efforts of audit team for unstinted support in carrying out this audit.

We thank our consultants, engineers and backup staff for their dedication to bring this report.

Thank you.

B V Suresh Babu
Accredited Energy Auditor
AEA 33, Bureau of Energy Efficiency

Preface

Educational institutions always had an important leadership role in society in demonstrating types of changes that used to occur with respect to the prime issues of the time. All around the world, educational institutions are taking steps to declare themselves the next carbon neutral school as a part of the global trend of becoming sustainable. In 2007, Victoria University School of Architecture and Design declared themselves the first carbon neutral campus in the world through the purchase of carbon credits. This concept is not a sustainable model as it does not guarantee the capture of carbon forever and also it is expensive.

The potential for any academic institution- (may be a school in a remote village or a university in an urban setting) - to become the driver for change is huge. Its role of practicing leadership in its community can be utilized to encourage and influence carbon neutral living.

The biggest factors that contribute towards emission are Energy, Transportation and Waste. Any reduction in the carbon emission by the above sectors, starts with the behavioral changes (Low cost) and/or technological investments (High cost). In order to make these changes, the students are to be educated properly on the concept of carbon neutral campuses and methods to reduce it.

In India, the concept of carbon neutral campuses is gaining momentum. Green Audit in Campuses measures the amount of Green House Gases (GHG) emissions produced as a result of its operations through an accounting like inventory of all the sources of GHGs and carbon sequestration in the school campus. Based on this, the total carbon footprint is estimated. Measures are recommended to bring down the carbon footprint of the campus and to make it a carbon neutral campus.

B Zachariah

Director, OTTOTRACTIONS

Contents

1

Introduction

Background

All across the developed countries, educational institutions are now moving to a sustainable future by becoming carbon neutral and greener spaces. They are taking responsibility for their environmental impact and are working to neutralize those effects. To become carbon neutral, institutions are working to reduce their emissions of greenhouse gases, cut their use of energy, use energy efficient equipment, use more renewable energy, plant and protect green cover and emphasize the importance of sustainable energy sources. Institutions that have committed to becoming carbon neutral have recognized the threat of global warming and are therefore committing to reverse the trend. Studies on this line has not struck roots in most of the developing countries-especially among students.

The Sustainable Development Goals (SDGs), launched by the United Nations in 2015, are an excellent vehicle for driving this change. They represent an action plan for the planet and society to thrive by 2030. The SDGs provide a window of opportunity for creating multidimensional operational approaches for climate change adaptation. They address poverty, hunger and climate change, among other issues central to human progress and sustainable development, such as gender equality, clean water and sanitation, and responsible consumption and production.

The Green Audit of **K.S.M.D.B College** aims to assist campus to reduce their carbon footprint and educate tomorrow's leaders about strategies for carbon mitigation using their campus as a model. Also, this audit covers institutes responses towards SDGs by covering SDG 3,6,7,11,13,15. The green audit also aims to educate students and teachers on the concept of carbon footprint and to enable

the students to collect data pertaining to the carbon emissions and carbon sequestration in their campus and to calculate the specific carbon footprint of the campus.

The project also suggests plans to make the campus carbon neutral or even carbon negative by implementing carbon mitigation strategies in areas such as,

a. Energy
b. Transportation
c. Waste minimisation
d. Carbon Sequestration etc.

The major objectives of the audit are:

- To make aware students and teachers on the concept of carbon footprint.
- To calculate the specific carbon footprint of the campus and classify it as carbon negative, neutral or positive.
- To create carbon mitigation plans to reduce their footprint based on the data generated.

Kumbalathu Sankupillai Memorial Devaswom Board College

KSMDB College, Sasthamcotta, established in 1964 in Kunnathur taluk, takes its place in the annals of the history of South Kerala as a revered institution for higher education managed by the Hon'ble Travancore Devaswom Board, and affiliated to the University of Kerala. The college is blessed at the entrance by the temple of Lord Dharma Sastha and is set in the beautiful serene locale on a landmass surrounded on three sides by the famous Sasthamcotta lake, the largest freshwater lake of Kerala and a Ramsar site, lending an aura of grace, reverence for the environment and sense of oneness with the grandeur of Nature. The college was recognised by the University Grants Commission under the 2 (f) and 12 (B) schemes in 1977 and 1979 respectively. Starting with Pre degree courses, the college now caters to the demands of students for 17 undergraduate programmes, 7 post graduate courses, 2 PhD programmes and 2 Diploma programmes. The college strives to provide holistic education so as to mould students into citizens who are endowed with a value system and environment consciousness, while pursuing their academic ambitions. Throughout its history spanning over 50 years, the college has believed in discharging its social responsibility as an abode of higher education in the public sector catering mostly to the less privileged sections of the society.

Occupancy Details				
Particulars	2018-19	2019-20	2020-21	2021-22
Total Students	2398	2501	2732	3000
Staffs	200	200	200	200
Total Occupancy of the college	2598	2701	2932	3200

For calculating per capita carbon emission estimation, only the student strength is taken into account.

Form-A											
BASELINE DATA SHEET FOR GREEN AUDIT											
1	Name of the Organisation	Devaswom Board College Sasthamcotta									
2	Address (include telephone, fax & e-mail)	K.S.M D.B College, Sasthamcotta 690521,0476-2830323, principal@ksmdbc.ac.in									
2	Year of Establishment	1964									
3	Name of building and total No. of Electrical Connections/building	1									
4	Total Number of Students	Boys	-	Girls	-	Total	3000				
5	Total Number of Staff	200									
6	Total Occupancy	3200									
7	Total area of green cover (Acre)										
8	Type of Electrical Connection	HT	-	LT	LT-6A/Three						
9	Contract Demand (KVA) /Connection	83									
10	Average Maximum Demand (KVA)	NA									
11	Total built up area of the building (M^2)	14066									
12	Number of Buildings	6									
13	Average system Power Factor	0.98									
14	Details of capacitors connected	NA									
15	Transformer Details (Nos., kVA, Voltage ratio)	TR 1	TR 2	TR 3	TR 4	TR 5	TR 6				
		NA	NA	NA	NA	NA	NA				
15	DG Set Details (kVA,)	DG1	DG2	DG3	DG4	DG5	Remarks				
		NA	NA	NA	NA	NA	NA				
16	Details of motors	Rating		Nos.		Remarks					
		5 to 10		NA		NA					
		10 to 50		NA		NA					
		Above 50		NA		NA					
17	Brief write-up about the firm and the energy/environmental conservation activities already undertaken.	LED installations, Tree Plantation, Nature Club									
18	Contact Person & Telephone number	Principal									
		9446124229									

2

METHODOLOGY

2.1. Sensitisation

Low Carbon campus initiatives are successful when everyone in the campus is engaged including students, teachers and staff. A team of students, teachers and staff were formed to participate in the audit. A sensitisation among students and teachers on the concept of carbon footprint was conducted.

During the audit the students and staffs were sensitised on the project and trained to be a part of the data collection team. This helped in conducting the survey in a participatory mode so that the awareness will penetrate to the grass root level. During the data collection field visit it was stressed that the team will spread these ideas to their homes and friends. This will help in a horizontal and vertical spread of the message to a wider group. It is assumed that through 3200 occupants of this campuses will reach same number of households. This message will spread to at least 12800 individuals approximately.

2.2 Estimation of carbon footprint

A carbon footprint is the amount of greenhouse gases—primarily carbon dioxide—released into the atmosphere by a particular human activity. A carbon footprint can be a broad measure or be applied to the actions of an individual, a family, an event, an organization, or even entire nation. It is usually measured as tons of CO_2 emitted per year, a number that can be supplemented by tons of CO_2-equivalent gases, including methane, nitrous oxide, and other greenhouse gases.

Global Warming Potential (GWP) is a measure of how much heat a greenhouse gas traps in the atmosphere up to a specific time horizon, relative to carbon dioxide. The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of one ton of a

gas will absorb over a given period of time, relative to the emissions of one ton of carbon dioxide (CO_2).

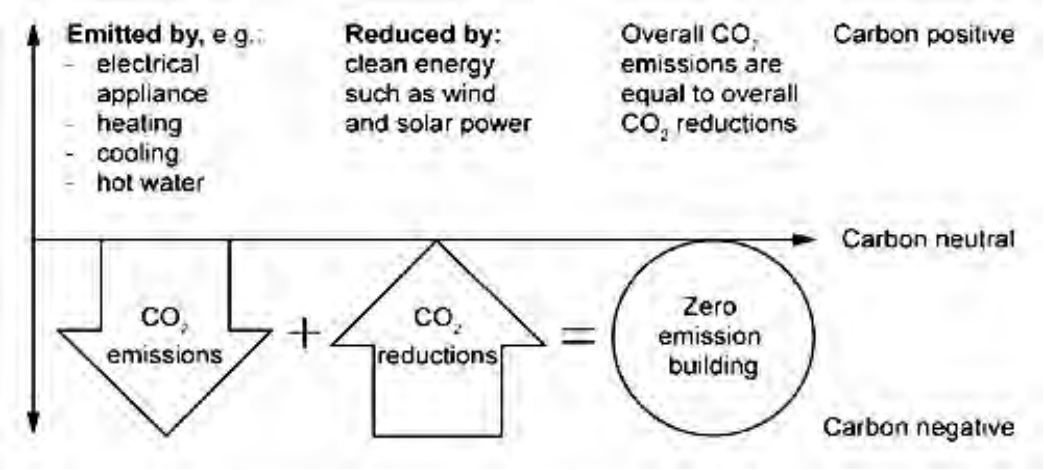
Global Warming Potentials (IPCC Second Assessment Report)					
Species	Chemical formula	Lifetime (years)	Global Warming		
			20 years	100 years	500 years
Carbon dioxide	CO2	variable §	1	1	1
Methane *	CH4	12±3	56	21	6.5
Nitrous oxide	N2O	120	280	310	170
HFC-23	CHF3	264	9100	11700	9800
HFC-32	CH2F2	5.6	2100	650	200
HFC-41	CH3F	3.7	490	150	45
HFC-43-10mee	C5H2F10	17.1	3000	1300	400
HFC-125	C2HF5	32.6	4600	2800	920
HFC-134	C2H2F4	10.6	2900	1000	310
HFC-134a	CH2FCF3	14.6	3400	1300	420
HFC-152a	C2H4F2	1.5	460	140	42
HFC-143	C2H3F3	3.8	1000	300	94
HFC-143a	C2H3F3	48.3	5000	3800	1400
HFC-227ea	C3HF7	36.5	4300	2900	950
HFC-236fa	C3H2F6	209	5100	6300	4700
HFC-245ca	C3H3F5	6.6	1800	560	170
Sulphur hexafluoride	SF6	3200	16300	23900	34900
Perfluoromethane	CF4	50000	4400	6500	10000
Perfluoroethane	C2F6	10000	6200	9200	14000
Perfluoropropane	C3F8	2600	4800	7000	10100
Perfluorobutane	C4F10	2600	4800	7000	10100
Perfluorocyclobutane	c-C4F8	3200	6000	8700	12700
Perfluoropentane	C5F12	4100	5100	7500	11000
Perfluorohexane	C6F14	3200	5000	7400	10700

The methodology for carbon footprint calculations are still evolving and it is emerging as an important tool for green house management. In the present study carbon emission data from the campus is estimated under four categories viz.

a. Energy
b. Transportation
c. Waste minimisation
d. Carbon Sequestration

Carbon neutrality refers to achieving net zero GHG emission by balancing the measured amount of carbon released into atmosphere due to human activities, with an equal amount sequestrated in carbon sinks. It is crucial to restrict atmospheric concentrations of GHGs released from various socio-economic, developmental and life style activities using biological

or natural processes. It is recognized that addressing climate change is not as simple as switching to renewable energy or offsetting GHG emissions. Rather, providing an opportunity for innovation in new developmental activities for viable and effective approach to address the problem.



Energy

In the campus carbon emission from energy consumption is categorised under two headings viz. energy from Electrical and Thermal. Energy used for transportation is calculated under transportation sector.

A detailed energy audit is conducted to understand the energy consumption of the campus. Information on total connected loads, their duration of usage and documents like electricity bills are evaluated. Connected loads are calculated by conducting a survey on electrical equipment on each location. Duration of usage was found out by surveying the users. The survey of equipment was conducted in a participatory mode.

The fuel consumption for cooking, like LPG, was studied by analysing the annual fuel bills and usage schedules during the study. Discussions were carried out with the concerned individuals who actually operate the cooking system.

Transportation

There is No vehicles operates from campus for its logistics.

Carbon emission from transportation to be calculated by using the following formula:

Carbon Emission = Number of each type of vehicles × Avg. fuel consumed per year ×

Emission factors (based on the fuel used by the vehicle)

Waste Minimisation

The waste generated from the campus is also responsible for the greenhouse gas emission. So, in order to calculate the total carbon foot print of the campus it is necessary to estimate the greenhouse gas emission from the waste generated in the campus by the activity of the students, teachers and staffs.

The calculation of the waste generated has been conducted by keeping measuring buckets for collecting the waste generated in a day. This waste so generated was calculated by weighing it.

Carbon Sequestration

Carbon sequestration is the process involved in the long-term storage of atmospheric carbon dioxide. Trees remove carbon dioxide from the atmosphere through the natural process of photosynthesis and store the carbon in their leaves, branches, stems, bark, and roots.

Carbon sequestrated by a tree can be found out by using different methods. Since this study is employed the volumetric approach, the calculation consists of five processes.

- Determining the total weight of the tree
- Determining the dry weight of the tree
- Determining the weight of carbon in the tree
- Determining the weight of CO_2 sequestrated in the tree
- Determining the weight of CO_2 sequestrated in the tree per year

Detailed calculations and results are given in the technical supplements of this document.

3

RESULTS AND DISCUSSIONS

3.1 CARBON FOOTPRINT ESTIMATION

3.1.1 ENERGY

a. Electricity

Electricity is purchased from KSEB under 1 LT Connection, the details are given below.

Electricity Connection Details		
Devaswom Board College Sasthamcotta		
1	Name of the Consumer	Devaswom Board College Sasthamcotta
2	Tariff	LT-6A/Three
3	Consumer Numbers	1145732000792
5	Connected Load (kW)	83.196
6	Annual Electricity Consumption (kWh)	334409

Electricity Bill Analysis

1145732000792		
Electricity Consumption Details(2021-22)		
Date	Amount	Consumption
April	36725	2039
May	33248	3911.5
June	9624	1132.2
July	34353	4036
August		
September	22083	2320
October	17986	1747
November	17986	1747
December		
January	50934	5992.2
February		
March		
Average	27867.375	2865.6
Total	334408.5	34387.5

Annual Electricity Consumption (kWh)			
Consumer No	2019-20	2020-21	2021-22
1145732000792	20632.5	17193.75	34387.5
Total	20633	17194	34388

Diesel

Diesel Consumption Details			
	2019-20	2020-21	2021-22
Litre(L)	240	80	200
Cost(Rs)	19200	7200	19200
Total	19440	7280	19400

LPG

LPG Consumption Details			
	2019-20	2020-21	2021-22
No Cylinders	48	12	40
LPG Consumption in kg	912	228	760

Base Line Energy Data				
Devaswom Board College Sasthamcotta				
		2019-20	2020-21	2021-22
1	Electricity KSEB (kWh)	20633	17194	34388
2	Electricity Solar - Off grid (kWh)	0.00	0.00	0.00
3	Electricity (KSEB + Off grid) kWh	20633	17194	34388
4	Electricity Grid Tied (kWh)	0.00	0.00	0.00
5	Diesel (L)	240.00	80.00	200.00
6	LPG (kg)	912.00	228.00	760.00
7	Biogas (kg)	0.00	0.00	0.00

Energy Consumption Profile				
Sl No	Fuel	2018-19	2019-20	2020-21
		(kCal)		
1	Electricity	17743950	14786625	29573250
2	Diesel	2520000	840000	2100000
3	LPG	10944000	2736000	9120000
4	Biogas	-	-	-
Total (kCal)		31207950	18362625	40793250
Total (kWh)		36288.31	21351.89	47434.01

Thermal Fuel Consumption			
Devaswom Board College Sasthamcotta			
	2019-20	2020-21	2021-22
Annual LPG consumption in kg	912	228	760
Annual Diesel consumption in L	240.00	80.00	200.00
Annual petrol consumption in L	0.0	0.0	0
Annual Biogas consumption in m3	-	-	-

Specific Energy Consumption

OTTOTRACTIONS- ENERGY AUDIT				
Devaswom Board College Sasthamcotta				
Energy Performance Index (EPI)				
Sl No	Particulars	2019-20	2020-21	2021-22
1	Total building area (m^2)	14066	14066	14066
2	Annual Energy Consumption (kCal)	31207950	18362625	40793250
3	Annual Energy Consumption (kWh)	36288.3	21351.9	47434.012
4	Total Energy in Toe	3.12	1.84	4.08
5	Specific Energy Consumption kWh/m^2	2.58	1.52	3.37

In 2020-21 the energy consumption was less due to lock down based on covid 19 pandemic. So, the specific energy consumption in 2021-22 may be taken as benchmark.

3.3. Waste Generation total

The major concern of waste management will be focused on the solid waste produced by the campus. Solid wastes produced in the campus are mainly of three types, food waste, paper waste, and plastic waste. Food wastes produced in the campus are mainly by two means. The vegetable wastes produced in the kitchen during the food preparation. The food waste produced by the students and staffs of the campus after the consumption of meals.

Degradable Waste

Degradable Waste Generation			
Devaswom Board College Sasthamcotta			
	2019-20	2020-21	2021-22
Total Occupancy	3200	3200	3200
Waste generated in kg /day	64	80	25.6
Waste generated in kg /Yr	8448	10560	3379.2

Non-Degradable waste

Solid non degradable Waste Generation			
Devaswom Board College Sasthamcotta			
	2019-20	2020-21	2021-22
Total Occupancy	3200	3200	3200
Waste paper generated in kg /day	0.64	0.71	0.32
Waste plastic generated in kg /day	0.96	1.07	0.48
Waste paper generated in kg /Yr	140.80	156.44	70.40
Waste plastic generated in kg /Yr	211.20	234.67	105.60

3.4. Transportation

There are no Vehicles operating for the college.

Carbon Emission Profile (2021-22)

Carbon emissions in the campus due to the day-to-day activities are calculated and is discussed below. The emission factors considered for estimation and its units are given.

Emission Factors		
Item	Factor	Unit
Electricity	0.00079	tCo_2e/kWh
LPG	0.0015	tCo_2e/kg
Diesel	0.0032	tCo_2e/kg
Petrol	0.0031	tCo_2e/kg
Food Waste	0.00063	tCo_2e/kg
Paper Waste	0.00056	tCo_2e/kg
Plastic Waste	0.00034	tCo_2e/kg

Carbon Foot Print

Carbon Foot Print							
Sl. No.	Particulars	2019-20	tCO2e	2020-21	tCO2e	2021-22	tCO2e
1	Electricity (kWh)	20633	16.30	17194	13.58	34388	27.17
2	Diesel (L)	240.00	0.77	80.00	0.26	200.00	0.64
3	LPG (kg)	912.00	1.37	228.00	0.34	760.00	1.14
4	Biogas (m3)	0.00	-	0.00	-	-	-
5	Degradable Waste in kg/yr.	7131	4.49	9676	6.10	3379.2	2.13
6	Paper Waste in kg/yr	118.84	0.07	143.34	0.08	70.40	0.04
7	Plastic Waste in kg/yr	178.27	0.06	215.01	0.07	105.60	0.04
Total Carbon Foot Print tCO2e/yr			23.06		**20.43**		31.15

3.5. CARBON SEQUESTRATION

All the activities including energy consumption and waste management have their equivalent carbon emission and they positively contribute to the carbon footprint of the campus. Carbon sequestration is the reverse process, at which the emitted carbon dioxide will get sequestrated according to the type of carbon sequestration employed. Even though there are many natural sequestration processes are involved in a campus, the major type of sequestration among them is the carbon sequestration by trees.

Carbon Sequestration			
Particulars	2018-19	2019-20	2020-21
Total number of trees	60	63	183
Carbon sequestrated by trees in the campus (tCO2e)	12.76	13.61	17.01

Trees sequestrate carbon dioxide through the biochemical process of photosynthesis and it is stored as carbon in their trunk, branches, leaves and roots. The amount of carbon sequestrated by a tree can be calculated by different methods. In this study, the volumetric approach was taken into account, thus the details including CBH (Circumference at Breast Height), height, average age, and total number of the trees, are required. Details of the trees in the campus compound are given in the Table 3.18. Detailed table is included in the technical supplement.

Carbon sequestrated by a tree can be found out by using different methods. Since this study is employed the volumetric approach, the calculation consists of five processes.

- Determining the total weight of the tree
- Determining the dry weight of the tree
- Determining the weight of carbon in the tree
- Determining the weight of CO_2 sequestrated in the tree
- Determining the weight of CO_2 sequestrated in the tree per year

Carbon sequestrated by each species of trees in the campus compound is given in the Table.3.19 Detailed calculation results are listed out in the tables provided in the technical supplements of 'Carbon sequestration'.

Form 5										
Sl. No	Name of tree (Botanical name)	Circumference (cm)	Stem diameter (cm)	Height of trees (m)	Total weight of tree	Weight of carbon	No.of similar trees	Total carbon sequest	Carbon Sequest rated by	Average age (years)
1	Mangifera indica (Mango tree)	140	44.56	6	494.72	0.29	14	4.126	0.295	16
2	Cocos nucifera	40	12.73	8	53.85	0.03	25	0.802	0.032	8
3	Artocarpus heterophyllus(Jack	130	41.38	9	639.86	0.38	9	3.431	0.381	22
4	Araucaria heterophylla (X'mas tree)	22	7.00	7	14.25	0.01	2	0.017	0.008	5
5	Spathodea campanulata	80	25.46	6	161.54	0.10	7	0.674	0.096	14
6	Caesalpinia sappan	28	8.91	6	19.79	0.01	3	0.035	0.012	6
7	Cassia fistula	23	7.32	6	13.35	0.01	7	0.056	0.008	3
8	Chamaecrista mimosoides	75	23.87	5	118.32	0.07	7	0.493	0.070	8
9	Pongamia pinnata	95	30.24	7	265.77	0.16	1	0.158	0.158	31
10	Artocarpus hirsutus	85	27.06	7	212.76	0.13	10	1.268	0.127	27
11	Syzygium cuminii	70	22.28	5	103.07	0.06	10	0.614	0.061	6
12	Bambusa tuldoides	10	3.18	6	2.52	0.00	10	0.015	0.002	6
13	Swietenia mahagoni	80	25.46	5	134.62	0.08	11	0.882	0.080	6
14	Tectona grandis	70	22.28	7	144.29	0.09	14	1.204	0.086	6
15	Casuarina equisetifolia	20	6.37	11	18.51	0.01	15	0.165	0.011	6
16	Anacardium occidentale	80	25.46	10	269.24	0.16	4	0.642	0.160	6
17	Phyllanthus emblica	70	22.28	6	123.68	0.07	15	1.105	0.074	6
18	Macaranga peltata	72	22.92	7	152.66	0.09	14	1.273	0.091	6
19	Aegle marmelos	40	12.73	6	40.39	0.02	1	0.024	0.024	6
20	Saraca indica	30	9.55	2	7.57	0.00	1	0.005	0.005	6
21	Plumeria alba	30	9.55	3	11.36	0.01	2	0.014	0.007	6
22	Plumeria rubra	27	8.59	4	12.27	0.01	1	0.007	0.007	6
						Total	183	17.01	1.7959	212

CARBON FOOTPRINT OF THE CAMPUS (2021-22)

Various carbon emitting activities such as consumption of energy, transportation and waste generation leads to the total emission of **31.15 tCO_2e** per year by the campus. The total carbon sequestration by trees in the campus compound is **17.01 tCO_2e**.

Thus, the current carbon footprint of the campus will be the difference of total carbon emission and total carbon sequestration/mitigation. The following table shows the carbon footprint level of 2021-22.

Specific CO2 Footprint

Amount of Carbon to be mitigated for Low Carbon Campus				
Sl No	Particulars	2019-20	2020-21	2021-22
1	Total carbon emission tCO2e	23.06	20.43	31.15
2	Total carbon sequestration tCO2e	12.76	13.61	17.01
3	Amount of carbon mitigated through renewable energy tCO2e	0.00	0.00	0.00
4	To be mitigated tCO2e	10.30	6.82	14.14
5	Total No of Students	2501	2732	3000
6	Specific Carbon Footprint kg CO2e/Student/Yr	4.12	2.50	4.71

The total specific carbon emission is estimated as **2.50** kg of CO_2e per student for the year 2020-21 and **4.71** kg of CO_2e per student for the year 2021-22. (The reduction in CO2 foot print is due to the impact of pandemic year)

4

Carbon Mitigation Plans

The total emission of the carbon dioxide per student is 4.71 kg per year (2021-22). Emission reduction plans were prepared to bring the existing per capita carbon footprint to zero or below so as to bring the campus a carbon neutral or carbon negative campus.

This can be achieved in many ways but, every alternate plan must be in such a way that, it must fulfill the actual purpose of each activity that is considered.

Here, three major methods are taken in to account as the plans for reducing the carbon emission of the campus.

- Resource optimisation
- Energy efficiency
- Renewable energy

RESOURCE OPTIMISATION

The effective use of resources can limit its unnecessary wastage. Optimal usage of the resources (such as fuels) can save the fuel and can also reduce the carbon emission due to its consumption. This technique can be effectively implemented in the 'transportation' and 'waste' sectors of the campus.

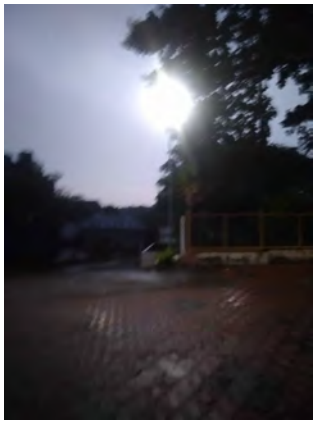
WASTE MINIMISATION

Optimal utilisation of paper and plastic stationaries can reduce the frequency of purchase of items. This can reduce the unnecessary wastage of money as well as the excess production of waste. In the case of food, proper food habits and housekeeping practices can optimise its usage.

Currently, the campus is taking an appreciable effort to reduce the unnecessary production of wastes. But the campus still has opportunities to reduce the generation of waste and can improve much more. Resource optimisation can be effectively implemented in all type of waste generated in the campus and the campus can expect about 50% reduction the total waste produced.

ENERGY EFFICIENCY

Energy efficiency is the practice of reducing the energy requirements while achieving the required energy output. Energy efficiency can be effectively implemented in all the sectors of the campus.



Solar lights

FUELS FOR COOKING

The campus uses commercial LPG cylinders for its cooking purpose. The campus can install a biogas plant to treat food waste and the biogas thus generated can be used in kitchen. Installation of a solar water heater to rise the water temperature to a much higher level, then it has to consume only very less amount of thermal energy for preparing the same amount of food is another method. This can make a positive benefit to the campus by saving money, energy and can reduce the carbon emission of the campus due to thermal energy consumed for cooking.

Biogas Plant

TRANSPORTATION

Energy efficiency of the transportation sector is mainly depended on the fuel efficiency of the vehicles used. Here mileage of the vehicle (kmpl - Kilometres per Litre) is calculated to assess the fuel efficiency of the vehicle.

Percentage of closeness is the ratio of actual mileage of the vehicle to its expected mileage. If the percentage of closeness of mileages of each vehicle is greater than that of its average, then the efficiency status of the vehicle is considered as 'Above average' and else, it is considered as 'Below average'

Carbon Mitigation Proposals

After analyzing the historical and measured data the following projects are proposed to make the campus carbon neutral. The projects are from energy efficiency and renewable energy. The further additions in the green cover increase will also give positive impact in the carbon mitigation.

OTTOTRACTIONS- ENERGY AUDIT						
Devaswom Board College Sasthamcotta						
Greenhouse Gas Mitigation through Major Energy Efficiency Projects						
Sl No	Projects	Energy saved(Yearly)		Sustainability (Years)	First year ton of CO_2 mitigated	Expected Tons of CO_2 mitigated through out life cycle
		(kWh)	MWh	Years		
1	Energy Saving in Lighting by replacing existing 217 No's T8 (40W) Lamps to 18 W LED Tube	**2826**	2.83	10	2.23	22.33
2	Energy Saving by replacing existing 332 No's in-efficient ceiling fans with Energy Efficient Five star fans	**5228**	5.23	10	4.13	41.30
Total		**8054**	**8**	**10**	**6.36**	**64**

OTTOTRACTIONS- ENERGY AUDIT						
Devaswom Board College Sasthamcotta						
Greenhouse Gas Mitigation through Renewable Energy Projects						
Sl No	Projects	Energy saved (Yearly)		Sustainability (Years)	First year ton of CO_2 mitigated	Expected Tons of CO_2 mitigated throughout life cycle
		(kWh)	MWh	Years		
1	Installation of 25kWp Solar Power Plant	**31938**	31.94	26	25.23	656.00
2	Installation of 15Kg/day Biogas plant	**5647**	5.65	20	4.46	89.22

OTTOTRACTIONS- ENERGY AUDIT	
Energy Saving Proposal Code EA 840.01	
Energy Saving in Lighting by replacing existing 217 No's T8 (40W) Lamps to 18 W LED Tube	
Existing Scenario	
217 numbers of T8(40 W) lamps were identified during the energy audit field survey in the facility. During discussion with officers it is observed that the average utility of these fittings are of 30%.	
Proposed System	
The existing T8 may be replaced to LED Tube of 18 W in phased manner and the savings will be of 67% (inclusive of improved light output and reduced energy consumption)	
Financial Analysis	
Annual working hours (hr)	1480
No of fittings	217
Total load (kW)	8.68
Annual Energy Consumption (kWh)	5139
Expected Annual Energy saving for replacing all fittings (kWh)	2826
Cost of Power	8.00
Annual saving in Lakhs Rs (1st year)	0.23
Investment required for complete replacements [@Rs 300 per fittings](Lakhs Rs)	0.65
Simple Pay Back (in Months)	34.55

Energy Saving Proposal Code EA 840.02	
Energy Saving by replacing existing 332 No's in-efficient ceiling fans with Energy Efficient Five star fans	
Existing Scenario	
There are 332 numbers of ceiling fans installed in the facility with minimum 8 hrs a day operation. All are conventional type and most of them are very old.	
Proposed System	
There is an energy saving opportunity in replace the existing fans with new five star labelled fans. The five star labelled fans give a savings up to 38% with higher service value (air delivery/watt).	
Financial Analysis	
Annual working hours (hrs)	1480
Total numbers of ordinary fans	332
Total load (kW)	23.24
Annual Energy Consumption (kWh)	13758
Expected Annual Energy saving, for total replacement(kWh)	5228
Cost of Power (Rs)	8.00
Annual saving in Lakhs Rs (1st year)	0.42
Investment required for replacing Fans (Lakhs Rs)[@2500 Rs per Fan for 5 Star Labelled Fans with service value above 6]	8.30
Simple Pay Back (in Months)	238.14

Energy Saving Proposal Code 785.03	
Installation of 25kWp Solar Power Plant	
Existing Scenario	
There is a good potential of solar power electricity generation. The availability of sunlight is very high. There are some canopies available in the proposed site, but by having proper trimming of trees this may be avoided. If the SPVs are place in the roof top it will help improving RTTV (Roof Thermal Transmit Value) of the building.	
Proposed System	
It is proposed to have a Solar Power Plant of 25kWp at the beginning stage. The state and central government is pushing and giving good assistance to the installation. It can be installed as an internal grid connected system which is much cheaper than off grid system. Now days the technology provides trouble free grid interactive and connected system. The installation will provide 25yrs trouble free generation with only 20% efficiency loss at the 25th year.	
Financial Analysis	
Proposed Solar installed Capacity (kW)	25
Total average kWh per day expected (3.5kWh/day average)	87.50
Total annual Generating Capacity (kWh)	31938
Cost of energy generated annually Lakhs Rs	2.56
Investment required (INR lakh)(Approx)	18.75
Simple Pay Back (in Months)	88.06
Life cycle in Yrs	25
Total Saving in Life Cycle (Approx) RS lakh	63.88

Sl.no	Installed 20Kg/day Biogas plant	
1	Capacity of Bio gas plant(Kg/day)	20
2	Average Calorific Value of biogas (kCal/m3)	3500
3	Annual Generation of Biogas Plant	1850
4	Daily production of biogas (kCal)	35000
5	LPG Saving in a day (kg)	2.917
6	Annual LPG Saving (Kg)	540
7	Investment required (in Lakhs)	0.2
8	Annual Cost saving (in Lakhs)	0.34
9	Expected Annual Energy saving (kWh)	7529
10	Simple Pay Back (In Months)	7.04

Executive Summary					
Consolidated Cost Benefit Analysis of Energy Efficiency Improvement Projects					
Devaswom Board College Sasthamcotta					
Sl No	Projects	Investment	Cost saving	SPB	Energy saved
		(Lakhs Rs)	(Rs)/Yr	Months	kWh/Yr
1	**Energy Saving in Lighting by replacing existing 217 No's T8 (40W) Lamps to 18 W LED Tube**	0.65	0.23	34.55	2826
2	**Energy Saving by replacing existing 332 No's in-efficient ceiling fans with Energy Efficient Five star fans**	8.30	0.42	238.14	5228
	Total	8.95	0.64	136.34	8054.28
(The saving are projected as per the assumed operation time observed based in the discussions with the plant officials. The data of saving percentages are taken from BEE guide books and field measurements.)					
Consolidated Cost Benefit Analysis of Renewable Energy Projects					
3	**Installation of 25kWp Solar Power Plant**	18.75	2.56	88.06	31938
4	**Installed 20Kg/day Biogas plant**	0.2	0.34	7.04	7529
	Total	18.95	2.90	47.55	39466.57

5
CONCLUSION

The carbon emission from different sectors namely, Energy, Transportation and wastes were calculated using standard procedures. Carbon sequestration by the trees present in the campus was also estimated. From these the total carbon footprint of the campus was arrived at.

Net Carbon Emission after implementing Energy Efficiency projects and Renewable Energy Projects Proposed		
1	Total Carbon Foot Print tCO2e/yr	31.15
2	Carbon Sequrested tCO2e/yr	17.01
3	Carbon mitigated by Renewable Energy tCO2e/yr (installed)	0.00
4	Carbon mitigated by Renewable Energy tCO2e/yr (Proposed) (Solar)	25.23
5	Carbon mitigated by Renewable Energy (Biogas Plant) (Proposed)	2.59
6	Carbon mitigated by Energy Efficiency (Proposed) tCO2e/yr	6.36
7	Effective Carbon footprint tCO2e/yr	-20.04
8	Total No of Students	3000.00
9	Specific Carbon Footprint kg CO2e/Student/Yr	-6.68

From this study it was found that carbon footprint of the campus to be **4.71** $kgCO_2e$/ Student/Year in place of current footprint i.e., -7.34 $kgCO_2e$/ student/ Year. This will be achieved after implementing energy efficiency projects and implementation of 25kWp solar power plant. To achieve this an investment of **27.90 lakhs Rs** is required through energy efficiency and renewable energy projects proposed. It will be around **930 Rs per student** to make the campus the carbon negative.

Cost to make the campus Carbon Negative		
1	Cost of implementation in Energy Efficiency Lakhs Rs	8.95
2	Cost of implementation in Renewable Energy Lakhs Rs	18.95
3	Total Lakhs Rs	27.90
4	Total number of students	3000
5	Cost per student to make the campus carbon negative Rs/ Student	930.0

REFERENCES

Reports and Books

- Towards campus climate neutrality: Simon Fraser University's carbon footprint (2007), Simon Fraser University, Bokowski, G., White, D., Pacifico, A., Talbot, S., DuBelko, A., Phipps, A.
- The bare necessities: How much household carbon do we really need? Ecological Economics (2010), 69, 1794–1804, Druckman, A., & Jackson, T.
- Home Energy Audit Manual (2017), Ottotractions & EMC Kerala, No.ES 26, Pp.114
- Screening of 37 Industrial PSUs in Kerala for Carbon Emission Reduction and CDM Benefits, (2011), Ottotractions & Directorate of Environment & climate Change, Kerala, No. ES-8, Pp.157

Website

- http://www.moef.nic.in/downloads/public-information/Report_INCCA.pdf
- https://ghgprotocol.org/sites/default/files/standards_supporting/Ch5_GHGP_Tech
- https://www.sciencedirect.com/science/article/pii/S0921344915301245
- http://www.kgs.ku.edu/Midcarb/sequestration.shtml
- http://www.sustainabilityoutlook.in/content/5-things-consider-you-plan-rooftop-pv-plant
- https://www.nrs.fs.fed.us/pubs/jrnl/2002/ne_2002_nowak_002.pdf
- https://www.ipcc-nggip.iges.or.jp/EFDB/find_ef.php
- https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion- factors-2018
- https://www.carbonfootprint.com/factors.aspx
- http://cea.nic.in/reports/others/thermal/tpece/cdm_co2/user_guide_ver10.pdf
- https://beeindia.gov.in/sites/default/files/guidebook-Campus.pdf
- https://www.elgas.com.au/blog/389-lpg-conversions-kg-litres-mj-kwh-and-m3
- http://www.sustainabilityoutlook.in/content/5-things-consider-you-plan-rooftop-pv-plant
- https://www.nrcan.gc.ca/energy/efficiency/transportation/20996
- https://www.americangeosciences.org/critical-issues/faq/how-does-recycling-save energy

OTTOTRACTIONS
Energy-Engineering-Environment

6

TECHNICAL SUPPLEMENT

Devaswom Board College Sasthamcotta															
Sl.No		Location	LIGHT					FAN			IT			AC	
			LED T	LED B	T8	T12	CFL	CF	EF	PF	PC	Printer	Scanner	1	1.5tr
1	Ground	Physics Block			4			6							
2		Physics Lab			5	3		6							
3		Classroom			1			2							
4		Dark room			2	2		3							
5		Exam hall			2	1		3							
6		Economics-1				2		3							
7	First Floor	BA English UG -3			6			6							
8		PG-2			2			4							
9		Dept of English			4			6							
10		Dept of Ecconomics			2			4							
11		PG-2			2			2							
12		UG-3			3			6							
13		Dept of Sanskrit	2		1			6							
14		UG-3			2			6							
15		PG-2			2			2							
16		Seminar hall			12			13							
17		General Library			15	7	3	18		3	2	1			

18		IQAC Room			2		3			2					
19		Reading room			3	1		4							
20		Stat class			2			2							
21		Malayalam dept	1		2			4							
22		Class*3			6			12							
23		UG-3			6			9							
24		Hindi Dept				1		1							
25		Dept of maths		2	2			3							
26		HOD		1				1							
27		UG-3			9			9							
28		PG-2			4			6							
29	Ground	Dept of Statistics			3	2		4							
30		Lab			4			3			8	2	1	1	
31		Office	7		4	2		9			5	1			
32		Dept of Politics	4		1			4			2	1			
33		UG-3			3			9							
34		Dept of Botony			3			3							
35		UG-2			6			6							
36		Zoology Lab		8				3							
37		Botony Lab			11			4							
38		Zoology Class*2			4			6							
39	Chemistry Block	Dept of chemistry	2	2	1			4							
40		HOD					1	1							
41		Lab*4		6		10			5						

42		Research lab *2		4		8			3						
43		Class*5	5				1	5							
44		PG-2	1				4	2							
45		Room	1		3	1									1
46		ResearchLab	1		1		1			1					
47		UG*5	5		5			10							
		Inst Room 2				4		4							
		MSC lab				2		2							
		Eng PG*3			3			9							
		Womens center			8	2		10							
		Lab			2			4							
		Bcom*2			2			4							
		Sanskrit			2			3							
	Commerce	Dept of Commerce	1		2			4							
		Corridor	4												
		Class*2			2			4							
		FF	3		9			8							
		Class*9			18			27							
48		Class*3			3			3			2	1	1		
		Auditorium			16			30							
TOTAL			**37**	**23**	**217**	**48**	**13**	**332**	**8**	**6**	**19**	**6**	**2**	**1**	**1**
W			20	10	40	55	20	80	70	70	100	140	160	1200	2200
			740	230	8680	2640	260	26560	560	420	1900	840	320	1200	2200

List of Trees in the Campus (above 15 cms growth)		
Sl No.	**Tree**	No:
1	Mangifera indica (Mango tree)	14
2	Cocos nucifera	25
3	Artocarpus heterophyllus(Jack Fruit)	9
4	Araucaria heterophylla (X'mas tree)	2
5	Spathodea campanulata	7
6	Caesalpinia sappan	3
7	Cassia fistula	7
8	Chamaecrista mimosoides	7
9	Pongamia pinnata	1
10	Artocarpus hirsutus	10
11	Syzygium cuminii	10
12	Bambusa tuldoides	10
13	Swietenia mahagoni	11
14	Tectona grandis	14
15	Casuarina equisetifolia	15
16	Anacardium occidentale	4
17	Phyllanthus emblica	15
18	Macaranga peltata	14
19	Aegle marmelos	1
20	Saraca indica	1
21	Plumeria alba	2
22	Plumeria rubra	1