GREEN AUDIT REPORT

VTM NSS COLLEGE

DHANUVACHAPURAM

Executed by

OTTOTRACTIONS
Energy - Engineering - Environment

2023

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OTTOTRACTIONS
Energy - Engineering - Environment

aea@ottotractions.com, otenergy@gmail.com
www.ottotractions.com

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Accredited Energy Auditor:AEA-33
Bureau of Energy Efficiency
Government of India.

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Green Audit Report
VTM NSS College, Dhanuvachapuram
Report No: EA 1093/GA
2023

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, ISO 17020-2012 and ISO 14001-2015 Certified organization, which ensures the quality of its services.

Acknowledgment

We were privileged to work together with the administration and staff of VTM NSS College, Dhanuvachapuram. We are grateful to them for the timely help extended to complete the audit and bringing out this report.

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
Government of India

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

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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 **VTM NSS College, Dhanuvachapuram** 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.

VTM NSS COLLEGE

The Nair Service Society established VTM-NSS College in 1964 in commemoration of the great freedom fighter, Thalakulathu Velu Thampi Dalava, on the occasion of his 200th birth anniversary.VTMNSS College is situated on a hillock at Dhanuvachapuram, en route to Kanayakumari, which is on the southernmost tip of Kerala. The idyllic environs of the college provide a congenial ambience for academic pursuits.The college started off modestly as a junior college on July 15, 1964 in a temporary building and has now developed into a full- fledged first grade college. It was upgraded in 1967 with the commencement of Degree Courses in English, History, Politics Science, Mathematics, Physics, Chemistry, and Commerce. Degree Courses in Economics and Botany were started in 1981.

Degree courses in Zoology and Malayalam were introduced in 1984 and 1995 respectively. The college attained the status of a first grade college when the Post Graduate course in Commerce was begun in 1981 followed by the Post Graduate course in English in 1998 and History in 1999.The college scaled great heights despite the impediments that generally come in the way of a college in a rural backdrop. More than 80 per cent of the students come from financially challenged families of peasants, fishermen, coolies and people engaged in the unorganized traditional sectors like handloom weaving, masonry and pottery making. Their only means of sustenance in education is the fee concession allowed by the State Government and a few scholarships.

Occupancy Details					
Particulars	2018-19	2019-20	2020-21	2021-22	2022-23
Total Students	1739	1757	1675	1832	1746
Staffs	62	61	60	62	58
Total Occupancy of the college	1801	1818	1735	1894	1804

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

BASELINE DATA SHEET FOR GREEN AUDIT											
1	Name of the Organisation	VTM NSS College, Dhanuvachapuram									
2	Address (include telephone, fax & e-mail)	VTM NSS College Dhanuvachapuram, Thiruvananthapuram, Kerala-695503 0471-223 2240 principal@vtmnsscollege.ac.in									
3	Year of Establishment	1964									
4	Name of building and Total No. of Electrical Connections/building	NSS College (5)									
5	Total Number of Students	Boys	-	Girls	-	Total	1746				
6	Total Number of Staff	58									
7	Total Occupancy	1804									
8	Total area of green cover	50%									
9	Type of Electrical Connection	HT	0	LT	5						
10	Total Connected Load (kW)	70									
11	Average Maximum Demand (KVA)	-									
12	Total built up area of the building (M^2)	4524.73									
13	Number of Buildings	4									
14	Average system Power Factor	0.99									
15	Details of capacitors connected	Nil									
16	Transformer Details (Nos., kVA, Voltage ratio)	TR 1									
		0									
17	DG Set Details (kVA)	DG1	DG2	DG3	DG4	DG5	Remarks				
		30									
18	Details of motors	Rating		Nos.		Remarks					
		5 to 10		2							
		10 to 50									
		Above 50									
19	Brief write-up about the firm and the energy/environmental conservation activities already undertaken.	Installed Solar Street Lights and 5kWp Solar power plant, Energy conservation projects and Rain water harvesting									
20	Contact Person & Telephone number	Principal									
		04712232240									

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 1804 occupants of these campuses will reach same number of households. This message will spread to at least 7216 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

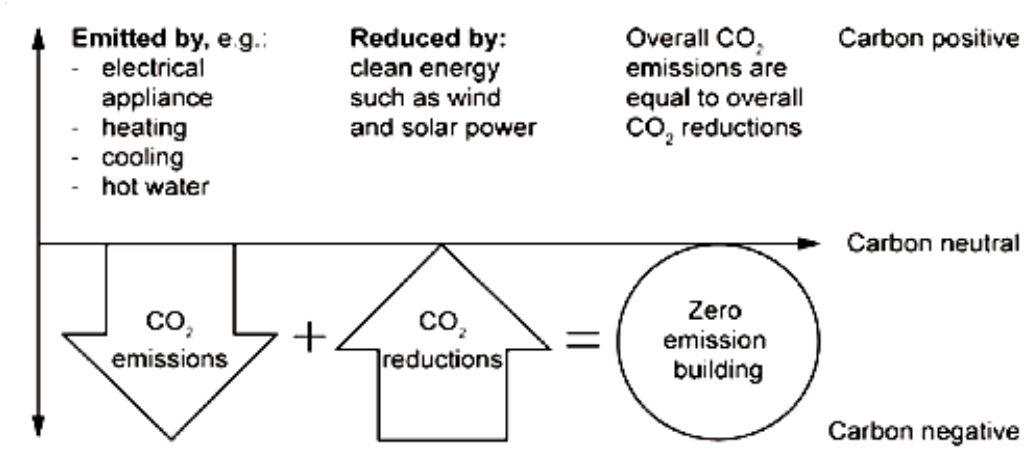
warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of one ton of a gas will absorb over a given period of time, relative to the emissions of one ton of carbon dioxide (CO_2).

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

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 below.

Step 1: Determine the total green weight of the tree

The green weight is the weight of the tree when it is alive. First, you have to calculate the green weight of the above-ground weight as follows:

W above-ground= 0.25 D2 H (for trees with D<11)

W above-ground= 0.15 D2 H (for trees with D>11)

W above-ground= Above-ground weight in pounds

D = Diameter of the trunk in inches

H = Height of the tree in feet

The root system weight is about 20% of the above-ground weight. Therefore, to determine the total green weight of the tree, multiply the above-ground weight by 1.2:

$W_{\text{total green weight}} = 1.2 * W_{\text{above-ground}}$

Step 2: Determine the dry weight of the tree

The average tree is 72.5% dry matter and 27.5% moisture. Therefore, to determine the dry weight of the tree, multiply the total green weight of the tree by 72.5%.

$W_{\text{dry weight}} = 0.725 * W_{\text{total green weight}}$

Step 3: Determine the weight of carbon in the tree

The average carbon content is generally 50% of the tree's dry weight total volume. Therefore, in determining the weight of carbon in the tree, multiply the dry weight of the tree by 50%.

$W_{\text{carbon}} = 0.5 * W_{\text{dry weight}}$

Step 4: Determine the weight of carbon dioxide sequestered in the tree

CO_2 has one molecule of Carbon and 2 molecules of Oxygen. The atomic weight of Carbon is 12 (u) and the atomic weight of Oxygen is 16 (u). The weight of CO_2 in trees is determined by the ratio of CO_2 to C is 44/12 = 3.67. Therefore, to determine the weight of carbon dioxide sequestered in the tree, multiply the weight of carbon in the tree by 3.67. $W_{\text{carbon-dioxide}} = 3.67 * W_{\text{carbon}}$

3

RESULTS AND DISCUSSIONS

3.1 CARBON FOOTPRINT ESTIMATION

3.1.1 ENERGY

a. Electricity

Electricity is purchased from KSEB under 5 LT Connections, the details are given below.

Electricity Connection Details		
VTM NSS College, Dhanuvachapuram		
1	Name of the Consumer	VTM NSS College, Dhanuvachapuram
2	Tariff	LT-6A/Ndom
3	Consumer Numbers	1145383023343, 1145384000482 1145382000488, 1145386000487 1145388000570
4	Connected Load Total (kW)	70
5	Annual Electricity Consumption (kWh)	23260

Electricity Bill Analysis

Year	18-19	19-20	20-21	21-22	22-23
CONSUMER NO	1145383023343				
APR	4409	4680		3163	3871
JUN	2659	3009	4486	3086	3145
AUG	2739	4743		861	2760
OCT	2768	3972	2504	2454	2697
DEC	3158	3564	3025	2215	3683
FEB		3184	3841	2215	3802

Year	18-19	19-20	20-21	21-22	22-23
CONSUMER NO		1145384000482			
APR	3053	5088			4345
JUN	1621	2140	5852		1494
AUG	3704	26293	2723	3968	3351
OCT	3208	8267	609	817	3108
DEC	8894	8267	671	1613	4034
FEB	4525	8267	2729	2884	3829

Year	18-19	19-20	20-21	21-22	22-23
CONSUMER NO		1145382000488			
APR	1263	2339		2229	2811
JUN	1836	3743	3791	1721	2418
AUG	718	2785	1481	778	3452
OCT	2061	2392	1376	1977	4054
DEC	3667	2630	1071	2505	4246
FEB	3004	2975	2205	2222	4954

Year	18-19	19-20	20-21	21-22	22-23
CONSUMER NO		1145386000487			
APR	3958	2252		2963	2279
JUN	5661	1557	3396	1954	1980
AUG	3172	2068	1725	922	22225
OCT	3074	2305	1683	1765	2317
DEC	2603	2318	1829	3763	2832
FEB	3280		1955	2580	2947

Year	18-19	19-20	20-21	21-22	22-23
CONSUMER NO		1145388000570			
APR	21317	31197	7946	12174	13501
JUN	19767	19627	995	3419	15044
JUL				5817	10338
AUG	20920	23922	7677	8327	9586
SEP				6439	12025
OCT	19214	27629	10597	7612	8346
NOV		14429	2980	7905	10778
DEC	22237	10951		9978	10338
JAN		10,397		9277	13234
FEB	25307	111,87	9658	12142	9519

Annual Electricity Consumption (kWh)						
Consumer No	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**Connected Load (kW)**
1145383023343	1748	2572	1540	1555	2218	16
1145384000482	2778	6480	1398	1031	2240	8
1145382000488	1394	1874	1103	1270	2437	3
1145386000487	2416	1167	1176	1550	3842	8
1145388000570	14307	16609	6023	10198	12523	35
TOTAL	22644	28702	11240	15604	23260	70

LPG

LPG Consumption Details					
	2018-19	2019-20	2020-21	2021-22	2022-23
No Cylinders	17	16	12	15	18
Canteen/Lab LPG Consumption in kg	319.2	243.0	180.0	225.0	270.0
Total in kg	319.2	243.0	180.0	225.0	270.0

Solar Power Plant		
Location	**Capacity (kWp)**	**2022-23**
		Annual generation (kWh)
College Campus	5	6388
Total kWh		6388

Base Line Energy Data						
VTM NSS College, Dhanuvachapuram						
		2018-19	2019-20	2020-21	2021-22	2022-23
1	Electricity KSEB (kWh)	22644	28702	11240	15604	23260
2	Electricity DG (kWh)	825	841	859	876	894
3	Electricity Solar , Off grid (kWh)	1473	1503	1534	1565	1597
4	Electricity (KSEB + DG + Off grid) kWh	24942	31047	13633	18045	25751
5	Electricity Grid Tied (kWh)	5892	6012	6135	6260	6388
6	Diesel (L)	274.87	280.48	286.20	292.04	298.0
7	LPG (kg)	319.20	243.00	180.00	225.00	270.00
8	Biogas generated/year (kg)	0.00	0.00	0.00	0.00	0.00

Energy Consumption Profile						
Sl No	Fuel	2018-19	2019-20	2020-21	2021-22	2022-23
		kCal				
1	Electricity	21449789	26700279	11724010	15518749	22146039
2	Diesel	2886090	2944990	3005092	3066420	3129000
3	LPG	3830400	2916000	2160000	2700000	3240000
4	Biogas	0	0	0	0	0
Total		28166279	32561269	16889102	21285169	28515039

Thermal Fuel Consumption VTM NSS College, Dhanuvachapuram					
	2018-19	2019-20	2020-21	2021-22	2022-23
Annual LPG consumption in kg	319.2	243.0	180.0	225.0	270.0
Annual Diesel consumption in L	274.9	280.5	286.2	292.0	298.0
Annual petrol consumption in L	0	0	0	0	0
Annual Biogas consumption in kg	0.00	0.00	0.00	0.00	0.00

3.2. Specific Energy Consumption

OTTOTRACTIONS- ENERGY AUDIT VTM NSS College, Dhanuvachapuram Energy Performance Index (EPI)						
Sl No	Particulars	2018-19	2019-20	2020-21	2021-22	2022-23
1	Total building area (m^2)	4524.73	4524.73	4524.73	4524.73	4524.73
2	Annual Energy Consumption (kCal)	28166279	32561269	16889102	21285169	28515039
3	Annual Energy Consumption (kWh)	32751	37862	19638	24750	33157
4	Total Energy in Toe	2.82	3.26	1.69	2.13	2.85
5	Specific Energy Consumption kWh/m^2	7.24	8.37	4.34	5.47	7.33

The specific energy consumption in 2022-23 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					
VTM NSS College, Dhanuvachapuram					
Particulers	2018-19	2019-20	2020-21	2021-22	2022-23
Total Occupancy	1801	1818	1735	1894	1804
Waste generated in kg /day	36.02	36.36	34.7	37.88	36.08
Waste generated in kg /Yr	7924.4	7999.2	7634	8333.6	7937.6

Non-Degradable waste

Solid non degradable Waste Generation					
VTM NSS College, Dhanuvachapuram					
Particulers	2018-19	2019-20	2020-21	2021-22	2022-23
Total Occupancy	1801	1818	1735	1894	1804
Waste paper generated in kg /day	0.3602	0.3636	0.347	0.3788	0.3608
Waste plastic generated in kg /day	0.5403	0.5454	0.5205	0.5682	0.5412
Waste paper generated in kg /Yr	79.24	79.99	76.34	83.34	79.38
Waste plastic generated in kg /Yr	118.87	119.99	114.51	125.00	119.06

3.4. Transportation

The college have no vehicles for logistics

Carbon Emission Profile (2022-23)

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

Emission Factors		
Item	Factor	Unit
Electricity	0.00082	tCo2e/kWh
Diesel	0.0032	tCo2e/kg
LPG	0.0015	tCo2e/kg
Biogas	0.0014	tCo2e/kg
Petrol	0.0031	tCo2e/kg
Food Waste	0.00063	tCo2e/kg
Paper Waste	0.00056	tCo2e/kg

Carbon Foot Print 2022-23

Carbon Foot Print											
Sl. No.	Particulars	2018-19	tCO2e	2019-20	tCO2e	2020-21	tCO2e	2021-22	tCO2e	2022-23	tCO2e
1	Electricity (kWh)	24942	20.45	31047	25.46	13633	11.18	18045	14.80	25751	21.12
2	Diesel (L)	274.87	0.88	280.48	0.90	286	0.92	292	0.93	298	0.95
3	LPG (kg)	319.20	0.48	243.00	0.36	180	0.27	225	0.34	270.00	0.41
4	Biogas (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
5	Degradable Waste in kg/yr.	7924.4	4.99	7999.2	5.04	7634.0	4.81	8333.6	5.25	7937.6	5.00
6	Paper Waste in kg/yr	79.24	0.04	79.99	0.04	76.34	0.04	83.34	0.05	79.38	0.04
Total Carbon Foot Print tCO2e/yr			26.85		31.80		17.22		21.37		27.52

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					
Particulers	2018-19	2019-20	2020-21	2021-22	2022-23
Total No of Trees	167	167	167	167	167
Carbon sequestrated by trees in the campus (tCO2e)	6.5	7.2	8.0	8.9	9.84

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. 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 FOOTPRINT OF THE CAMPUS (2022-23)

Various carbon emitting activities such as consumption of energy, transportation and waste generation leads to the total emission of **50.99 tCO_2e** per year by the campus. The total carbon sequestration by trees in the campus compound is **9.84 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:

Specific CO2 Footprint

Amount of Carbon to be mitigated for Low Carbon Campus						
Sl No	Particulars	2018-19	2019-20	2020-21	2021-22	2022-23
1	Total carbon emission tCO2e	26.85	31.80	21.37	27.52	27.52
2	Total carbon sequestration tCO2e	6.46	7.17	7.97	8.86	9.84
3	Amount of carbon mitigated through renewable energy tCO2e	4.83	4.93	5.03	5.13	5.24
4	To be mitigated tCO2e	15.56	19.70	8.37	13.53	12.44
5	Total No of Students	1801	1818	1735	1894	1804
6	Specific Carbon Footprint kg CO2e/Student/Yr	8.64	10.84	4.82	7.14	6.90

The total specific carbon footprint is estimated as **6.90** kg of CO_2e per student for the year 2022-23.

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Carbon Mitigation Plans

The total emission of the carbon dioxide per student is **16.39** kg per year (2022-2023). 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.

FUELS FOR COOKING

The campus 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.

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						
VTM NSS College, Dhanuvachapuram						
Greenhouse Gas Mitigation through Major Energy Efficiency Projects						
Sl No	Projects proposed	Energy saved(Yearly)		Sustainability (Years)	First year ton of CO2 mitigated	Expected Tons of CO2 mitigated through out life cycle
		(kWh)	MWh	Years		
1	Energy Saving in Lighting by replacing existing 3 No's T8 (40W) Lamps to 18W LED Tube	63	0.06	10	0.05	0.46
2	Energy Saving in Lighting by replacing existing 7 No's T12 (55W) Lamps to 18W LED Tube	186	0.19	10	0.14	1.36
3	Energy Saving by replacing existing 123 No's in-efficent ceiling fans with Energy Efficient Five star fans	2314	2.31	10	1.69	16.89
Total		**2563**	**3**	**10**	**1.87**	**18.71**

OTTOTRACTIONS- ENERGY AUDIT						
VTM NSS College, Dhanuvachapuram						
Greenhouse Gas Mitigation through Renewable Energy Projects						
Sl No	Projects	Energy saved (Yearly)		Sustainability (Years)	First year ton of CO2 mitigated	Expected Tons of CO2 mitigated through out life cycle
		(kWh)	MWh	Years		
1	Installation of 15kWp Solar Power Plant	20531	20.53	25	14.99	374.70

OTTOTRACTIONS- ENERGY AUDIT	
Energy Saving Proposal	
Energy Saving in Lighting by replacing existing 3 No's T8 (40W) Lamps to 18W LED Tube	
Existing Scenario	
3 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 18W in phased manner and the savings will be of 55% (inclusive of improved light output and reduced energy consumption)	
Financial Analysis	
Annual working hours (hr)	2400
No of fittings	3
Total load (kW)	0.12
Annual Energy Consumption (kWh)	115
Expected Annual Energy saving for replacing all fittings (kWh)	63
Cost of Power	7.46
Annual saving in Lakhs Rs (1st year)	0.00
Investment required for complete replacements [@Rs 300 per fittings](Lakhs Rs)	0.01
Simple Pay Back (in Months)	22.85

OTTOTRACTIONS- ENERGY AUDIT	
Energy Saving Proposal	
Energy Saving in Lighting by replacing existing 7 No's T12 (55W) Lamps to 18W LED Tube	
Existing Scenario	
7 numbers of T12(55 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 T12 may be replaced to LED Tube of 18W 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)	2400
No of fittings	7
Total load (kW)	0.39
Annual Energy Consumption (kWh)	277
Expected Annual Energy saving for replacing all fittings (kWh)	186
Cost of Power	7.46
Annual saving in Lakhs Rs (1st year)	0.01
Investment required for complete replacements [@Rs 300 per fittings](Lakhs Rs)	0.02
Simple Pay Back (in Months)	18.19

OTTOTRACTIONS- ENERGY AUDIT	
Energy Saving Proposal	
Energy Saving by replacing existing 123 No's in-efficent ceiling fans with Energy Efficient Five star fans	
Existing Scenario	
There are 123 numbers of ceiling fans installed in the facilty 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 30% with higher service value (air delivery/watt).	
Financial Analysis	
Annual working hours (hrs)	2400
Total numbers of ordinary fans	123
Total load (kW)	8.61
Annual Energy Consumption (kWh)	8266
Expected Annual Energy saving, for total replacement(kWh)	2314
Cost of Power (Rs)	7.46
Annual saving in Lakhs Rs (1st year)	0.17
Investment required for a total replacement (Lakhs Rs)[@3000 Rs per Fan with 50W at full speed]	3.69
Simple Pay Back (in Months)	256.47

Energy Saving Proposal	
Installation of 15kWp 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 35kW 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)	15
Total average kWh per day expected (3.5kWh/day average)	56.25
Total annual Generating Capacity (kWh)	20531
Cost of energy generated annually Lakhs Rs	2.73
Investment required (INR lakh)(Approx)	8.25
Simple Pay Back (in Months)	36.26
Life cycle in Yrs	25
Total Saving in Life Cycle (Approx) RS lakh	68.27

Executive Summary					
Consolidated Cost Benefit Analysis of Energy Efficiency Improvement Projects					
VTM NSS College, Dhanuvachapuram					
Sl No	Projects	Investment	Cost saving	SPB	Energy saved
		(Lakhs Rs)	(Rs)/Yr	Months	kWh/Yr
1	Energy Saving in Lighting by replacing existing 3 No's T8 (40W) Lamps to 18W LED Tube	0.01	0.005	22.85	63
2	Energy Saving in Lighting by replacing existing 7 No's T12 (55W) Lamps to 18W LED Tube	0.02	0.01	18.19	186
3	Energy Saving by replacing existing 123 No's in-efficent ceiling fans with Energy Efficient Five star fans	3.69	0.17	256.47	2314
4	Installation of 15kWp Solar Power Plant	8.25	2.731	36.26	20531
	Total	**11.97**	**2.92**	**83.44**	**23095**
(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.)					

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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	27.52
2	Carbon Sequrested tCO2e/yr	9.84
3	Carbon mitigated by Renewable Energy tCO2e/yr (Installed)	5.24
4	Carbon mitigated by Renewable Energy tCO2e/yr (Proposed)	14.99
5	Carbon mitigated by Energy Efficiency (Proposed) tCO2e/yr	1.87
6	Effective Carbon footprint tCO2e/yr	-4.42
7	Total No of Students	1746
8	Specific Carbon Footprint kg CO2e/Student/Yr	-2.53

From this study it was found that carbon footprint of the campus to be **-2.53** kgCO_2e/ Student/ Year in place of current footprint. To achieve this, an investment of **11.97Lakhs Rs** is required through energy efficiency and renewable energy projects proposed. It will be around **686 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	3.72
2	Cost of implementation in Renewable Energy Lakhs Rs	8.25
3	Total Lakhs Rs	11.97
4	Total number of students	1746
5	Cost per student to make the campus carbon negative Rs/ Student	686

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OTTOTRACTIONS
Energy-Engineering-Environment

6

TECHNICAL SUPPLEMENT

VTM NSS College, Dhanuvachapuram																
Sl.No	Location	Lights							Fans		IT			AC		Others	
		LED-T	LED-B	LED-SQ	LED(10W)	LED(200W)	T8	T12	CF	WF	Printer	Projector	PC	2Tr	1.5 TR	TV	Freezer
1	Classroom×4	4							4								
2	Classroom×3	18	6						12								
3	Computer Lab	7						2		4		1	45				
4	Principal	4			10				1	2	1	1	1		1	1	
5	PG Staffroom	2							2								
6	Dept of Botany	2							2								
7	Classroom	5						1	2			1					
8	Office	11					1	2	7		2		7				
9	Guest Room	2													1		
10	Dept of History Lecture Classroom	2							3								
11	Staff room	2							2								
12	Bsc Botany Lab	4							2			1					
13	Pg Dept of English	2							2								
14	Physical Education Dept	2							1								
15	6 Classrooms	12							6								
16	Malayalam Dept	3							2								
17	Dept of Maths	2							2								
18	Classroom	1							1								
19	Seminar Hall			15						8		1		4			
20	MA History Class	2							2								
21	3 Classrooms	12							9								
22	HOD Physics	2							1				1				

23	Physics Dept	2							1									
24	3 Lab	12							6									
25	Dept of English lab	2							1									
26	Classroom	4							2									
27	Chemistry Lab	4							3									
28	2 Classroom	8							6									
29	HOD Chemistry	1							1									
30	Dept of Chemistry	1							1									
31	Canteen		4				2		6									1
32	Commerce & Economics Block	4							2									
33	Classroom	3							2									
34	Classroom BA Economics	3							3									
35	II BA Economics×2	4							4									
36	Bcom Classroom	1							5									
37	Mcom Classroom	2							2									
38	2 Bcom Classrooms	4							4									
39	PG Commerce Dept	2							3									
40	Commerce HOD	1							1									
41	Library	2							3									
42	Mcom Ist &2nd Sem Class	3							2									
43	Solar					5												
44	NSS							2	2									
	Total	**164**	**10**	**15**	**10**	**5**	**3**	**7**	**123**	**14**	**3**	**5**	**54**	**4**	**2**	**1**	**1**	