# GREEN AUDIT REPORT

# MAR ATHANASIOS COLLEGE FOR ADVANCED STUDIES (MACFAST)

THIRUVALLA

Green Audit Report
MACFAST,
THIRUVALLA
Report No: EA
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## Green Audit Team

Ottotractions

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## 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.

# Acknowledgment

We were privileged to work together with the administration and staff of MACFAST, Thiruvalla for their 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 team OTTOTRACTIONS 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
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# 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 by the school 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

## 1.1 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 Mar Athanasios College For Advanced Studies (MACFAST), Thiruvalla, 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.

## Mar Athanasios College For Advanced Studies (MACFAST), Thiruvalla,

Mar Athanasios College for Advanced Studies Thiruvalla (MACFAST) is a premier post graduate research institute, established in 2001 with the objective of offering the best courses in Business Management, Information Technology and Biosciences to mould eminent professionals over the years to confront the challenging demands of the corporate world and the world of science & technology. MACFAST is affiliated to the Mahatma Gandhi University, Kottayam, and approved by the All India Council for Technical Education (AICTE), New Delhi. MACFAST is owned and managed by the Corporate Educational Agency of the Catholic Archdiocese of Thiruvalla, with His Grace Dr. Thomas Mar Koorilos as the President and Patron. Within a very short span of its existence, MACFAST has emerged as a trendsetter in education and has turned in to a benchmark for others to emulate with its unparalleled hallmark of academic brilliance and social commitment. The college is located in Tiruvalla, an active commercial township in the central Travancore region of Kerala. The two adjacent campuses together brings an idyllic character in shape and the atmosphere around pitches an ambience of solitude, of course, inevitable for intellectual pursuance. Amidst the lush green, stands this multi-storeyed building with a built-up area of 3,00,000 sq. ft.

.

| | |
|---|---|
| Students | 651 |
| Staff | 100 |
| Total Occupancy of the college | **751** |

Total student strength of the campus is 651. For calculating per capita carbon emission estimation, the student strength is taken into account.

# 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 751 occupants of this campuses will reach same number of households. This message will spread to at least 3000 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.

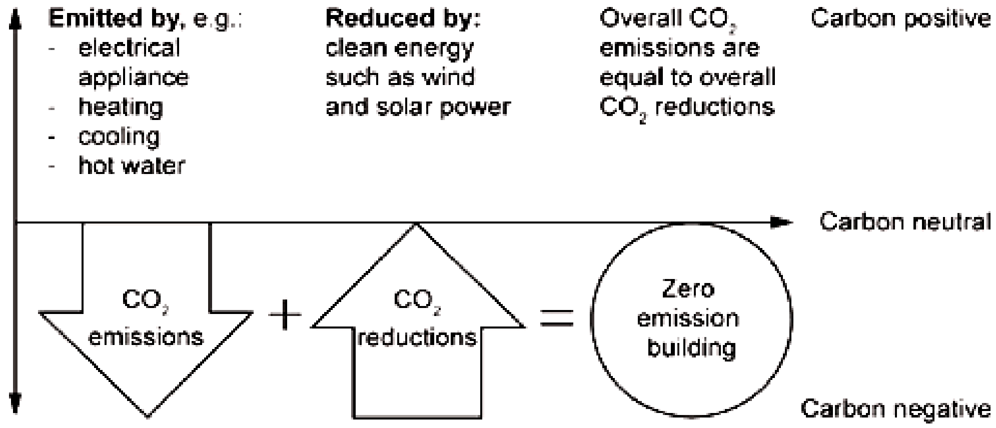
Global Warming Potential (GWP) is a measure of how much heat a greenhouse gas traps in the atmosphere up to a specific time horizon, relative to carbon dioxide. The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is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

The campus operates two college buses and three cars for its logistics.

Carbon emission from transportation is 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

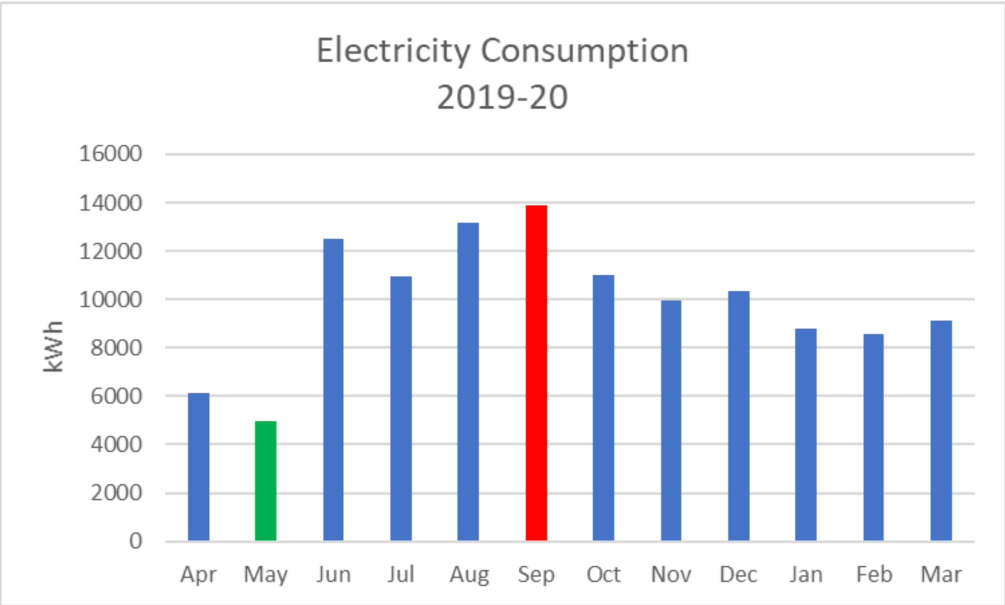
## 3.1.1 ENERGY

### a. Electricity

Electricity is purchased from KSEB under HT category. A 130 kWp grid tied Solar Power Plant is installed in the campus.

| Base Line Energy Data (2019-20)(Annual) | | |
|---|---|---|
| MACFAST THIRUVALLA | | |
| 1 | Annual Electricity Consumption (kWh) KSEB | 119420 |
| 2 | Annual Electricity Consumption (kWh)Solar | 166075 |
| 3 | Annual Diesel Consumption (L) | 1512 |
| 4 | Annual Electricity Cost (Lakhs Rs) | 1552460 |
| 5 | Annual Diesel Cost (Lakhs Rs) | 120953.00 |
| 6 | Total Annual Energy Cost (Lakhs Rs) | 1233016 |
| 7 | Rs/Kwh (avg) Electricity | 10.33 |

### Electricity Bill Analysis




- The total electricity consumption from KSEB was 119420kWh during the year 2019-20.
- The energy generation from solar power plant was 166075 kWh in the year 19-20
- The power factor maintained is 0.91 average, it has to be improved to unity to get energy cost reduction.

| | | |
|---|---|---|
| OTTOTRACTIONS- ENERGY AUDIT | | |
| MACFAST | | |
| Baseline Data (2019-20) | | |
| 1 | Electricity Provider | KSEB |
| 2 | Tariff | HT II(B) GENERAL |
| 3 | Contract Demand | 100 |
| 4 | Maximum Demand (avg in kVA) | 65 |
| 5 | Connected Load(kW) | 368.40 |
| 6 | Electricity Consumption kWh /Yr | 285495 |
| 7 | Electricity Consumption kWh /Yr KSEB | 119420 |
| 8 | Electricity Consumption kWh /Yr Solar | 166075 |
| 9 | Disel Consumption L/yr | 1512 |
| 10 | Disel in kWh/yr | 18459 |
| 11 | Biogas Production (m3)/yr | 12600 |
| 12 | Biogas Production (kWh)/yr | 73256 |
| 13 | LPG Consumption in kg/yr | 168 |
| 14 | LPG Consumption in kWh | 2344 |
| 15 | Total Energy Consumption (kWh)/yr | 379555 |
| 16 | Total Geen Energy (Renewable) kWh/yr | 239331 |
| 17 | Energy Cost (KSEB) (Lakhs Rs)/yr | 14 |
| 18 | Rs/Kwh(avg) (KSEB) | 10.57 |

## Specific Energy Consumption

| | | |
|---|---|---|
| OTTOTRACTIONS- ENERGY AUDIT | | |
| MACFAST | | |
| Energy Performance Index | | |
| 1 | Total Building area m2 | 16503 |
| 2 | Total Conditioned area | 1950 |
| 3 | % conditioned area | 12 |
| 4 | Annual Energy Consumption kWh | 213480 |
| 5 | Specific Energy Consumption kWh/m$^2$ | 12.94 |

## 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. The degradable waste is treated in the biogas plant, the biogas generated is used in the kitchen. Biogas plant is not in use now, it is strongly recommended to repair the same.

### Degradable Waste

| Degradable Waste Generation (2019-20) | |
|---|---|
| MACFAST THIRUVALLA | |
| Waste generated in kg per day | 11.265 |
| Waste generated in kg per Yr | 247 |

### Non-Degradable waste

| Solid non degradable Waste Generation (2019-20) | |
|---|---|
| MACFAST THIRUVALLA | |
| Non degradable Waste generated per day | 3 |
| Waste generated in kg per Yr | 74 |

## 3.4. Transportation

| Vehicles in the Campus | |
|---|---|
| Collage Bus | KLH 9917 |
| Collage Bus | KL 27 D 8689 |
| Innova | KL 27 E8 |
| Etios | KL27 E 3792 |
| EECO | KL 327 D 7672 |

The diesel consumed for vehicles was **7280** Litres as per logbook details

## Carbon Emission Profile (2018-19)

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 |
| LPG | 0.0031 | $tCo_2e/kg$ |
| Electricity | 0.00082 | $tCo_2e/kWh$ |
| Diesel | 0.0032 | $tCo_2e/kg$ |
| Food Waste | 0.00063 | $tCo_2e/kg$ |
| Paper Waste | 0.00056 | $tCo_2e/kg$ |
| Plastic Waste | 0.00034 | $tCo_2e/kg$ |

| Carbon Foot Print | | | |
|---|---|---|---|
| Sl. No. | Particulars | Remarks | Tonne of $CO_2$ e |
| 1 | Annual Electricity Consumption (kWh) Grid | 119420 | 97.9 |
| 2 | Annual LPG Consumption in kg | 168 | 0.3 |
| 3 | Annual Diesel Consumption (l) DG sets | 1512 | 4.8 |
| 4 | Annual Diesel Consumption (l) Transportation | 7280 | 23.3 |
| 5 | Annual Biogas Consumption in $m^3$ | 12600 | 17.6 |
| 6 | Food Waste in kg/yr. | 247 | 0.2 |
| 7 | Paper Waste in kg/yr | 74 | 0.0 |
| 8 | Plastic Waste in kg/yr | 50 | 0.0 |
| 9 | Total Carbon Foot Print $tCO_2e/yr$ | | 144.2 |

| CO2 mitigation details of 130kWe Solar Power Plant | | |
|---|---|---|
| Total Solar Capacity | 130 | kWe |
| Type | Grid Tied | |
| Total Solar Generation | 166075 | kWh |
| Total CO2 Mitigation through solar | 136.1815 | tCO2e |

## 3.4. 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.

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 Sequestration | |
|---|---|
| Particular | $tCO_2e$ |
| Carbon sequestration | 1.87 |

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’.

| Sl. No | Name of tree (common name/ scientific name) | Circumference | Stem diameter (cm) | Height of trees (m) |
|---|---|---|---|---|
| 1 | Swietenia mahagoni | 43 | 13.69 | 4 |
| 2 | Mimusops elengi | 33 | 10.50 | 5 |
| 3 | Teak | 48 | 15.28 | 7 |
| 4 | Acacia mangium | 31 | 9.87 | 8 |
| 5 | Hevea brasiliensis | 30 | 9.55 | 8 |
| 6 | Artocarpus heterophyllus | 45 | 14.32 | 8 |
| 7 | Boswellia sacra | 52 | 16.55 | 3 |
| 8 | Tamarindus indica | 43 | 13.69 | 8 |
| 9 | Cocos nucifera | 23 | 7.32 | 8 |
| 10 | Terminalia catappa | 28 | 8.91 | 4 |
| 11 | Elarocarpus serratus | 35 | 11.14 | 5 |
| 12 | Magnolia champaca | 36 | 11.46 | 6 |
| 13 | Mangifera indica | 34 | 10.82 | 6 |
| 14 | Pinus | 19 | 6.05 | 5 |
| 15 | Queen Palm | 18 | 5.73 | 5 |
| 16 | Nephelium lappaceum | 22 | 7.00 | 6 |
| 17 | Ficus carica | 22 | 7.00 | 5 |

## CARBON FOOTPRINT OF THE CAMPUS (2018-19)

Various carbon emitting activities such as consumption of energy, transportation and waste generation leads to the total emission of 144.16 $tCO_2$ e per year by the campus. The total carbon sequestration by trees in the campus compound is 1.87 $tCO_2$ e. and the total carbon mitigation through 130 kWe solar power generation is 153.82 tone of CO2.

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 2019-20.

| Low carbon status of the Campus | | | |
|---|---|---|---|
| Amount of carbon emission tCO2e | Amount of carbon sequestration tCO2e | Amount of carbon mitigated through renewable energy tCO2e | Effective Carbon emission tCO2e |
| 144.16 | 1.87 | 153.82 | -11.52 |

### Specific CO2 Footprint

| Total Carbon Emission | | |
|---|---|---|
| 1 | Total Carbon Foot Print tCO2e/yr | 144.16 |
| 2 | Amount of carbon mitigated through renewable energy tCO2e | 153.82 |
| 3 | Carbon sequestrated | 1.87 |
| 4 | Effective Carbon footprint | -11.52 |
| 5 | Total No of Students | 651 |
| 6 | Specific Carbon Footprint kg $CO_2$e/Student/Yr | -17.70 |

The total specific carbon emission is estimated as 144.16 kg of $CO_2$ e per student for the year 2019-20. As discussed earlier the campus already installed 130kWp solar power plant, which is a grid tied one. So now the effective CO2 mitigation has become -17.70 kg$CO_2$ /Student/Yr and the campus is now a carbon negative campus.

# 4

# Carbon Mitigation Plans

The total emission of the carbon dioxide per student is 144.16 kg per year. Emission reduction plans were prepared to bring the existing per capita carbon footprint to below zero so as to bring the campus a 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 installed one biogas plant to treat food waste and the biogas thus generated is used in kitchen.

The campus can install 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. 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'

## Renewable Energy

A 130kWp solar power plants is implemented in the campus which help offsetting the carbon foot print. The details of these projects are given in the concerned chapters.

## 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 | | | | | | |
|---|---|---|---|---|---|---|
| MACFAST THIRUVALLA | | | | | | |
| Greenhouse Gas Mitigation through Major Energy Efficiency 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 | Energy Saving in Lighting by replacing existing 447 No's T12 Lamps to 18W LED Tube | 19176 | 19.18 | 10 | 14.0<br>0 | 139.99 |
| 2 | Energy Saving in Lighting by replacing existing 28 No's T8 Lamps to 18W LED Tube | 1238 | 1.24 | 10 | 0.90 | 9.04 |
| 3 | Energy Saving in Lighting by replacing existing 12 No's T5 Lamps to 18W LED Tube | 53<br>1 | 0.53 | 10 | 0.39 | 3.87 |
| 4 | Energy Saving in Lighting by replacing existing 620 No's CFL Lamps to 9W LED Bulbs | 27416 | 27.42 | 10 | 20.0<br>1 | 200.14 |
| 5 | Energy Saving by replacing existing 770 No's in-efficient ceiling fans with Energy Efficient Five star fans | 22176 | 22.18 | 10 | 16.1<br>9 | 161.88 |
| | Total | 70538 | 71 | 10 | 51 | 51<br>5 |

| MACFAST THIRUVALLA | | | | | | |
|---|---|---|---|---|---|---|
| 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 |
| | | (kWh) | MWh | Years | | |
| 1 | Installation of 10 kW Solar Power Plant (proposed) | 12775 | 12.78 | 25 | 9.33 | 233.14 |

| OTTOTRACTIONS- ENERGY AUDIT | |
|---|---|
| Energy Saving in Lighting by replacing existing 447 No's T12 Lamps to 18W LED Tube | |
| Existing Scenario | |
| 447 numbers of T12 lamps were identified during the energy audit field survey in the facility. During discussion with staffs it is observed that the average utility of these fittings are of 80%. | |
| Proposed System | |
| The existing T12 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) | 2400 |
| No of fittings | 447 |
| Total load (kW) | 24.59 |
| Annual Energy Consumption (kWh) | 29502 |
| Expected Annual Energy saving for replacing all fittings (kWh) | 19176.30 |
| Cost of Power | 10.50 |
| Annual saving in Lakhs Rs (1st year) | 2.01 |
| Investment required for complete replacements [@Rs 450 per fittings](Lakhs Rs) | 2.01 |
| Simple Pay Back (in Months) | 11.99 |

| OTTOTRACTIONS- ENERGY AUDIT | |
|---|---|
| Energy Saving in Lighting by replacing existing 28 No's T8 Lamps to 18W LED Tube | |
| Existing Scenario | |
| 28 numbers of T8 lamps were identified during the energy audit field survey in the facility. During discussion with staffs it is observed that the average utility of these fittings are of 80%. | |
| Proposed System | |
| The existing T8 may be replaced to LED tube of 18 W 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 | 28 |
| Total load (kW) | 1.54 |
| Annual Energy Consumption (kWh) | 1848 |
| Expected Annual Energy saving for replacing all fittings (kWh) | 1238 |
| Cost of Power | 19176.30 |
| Annual saving in Lakhs Rs (1st year) | 237.43 |
| Investment required for complete replacements [@Rs 450 per fittings](Lakhs Rs) | 0.13 |
| Simple Pay Back (in Months) | 0.01 |

| OTTOTRACTIONS- ENERGY AUDIT | |
|---|---|
| Energy Saving in Lighting by replacing existing 12 No's T5 Lamps to 18W LED Tube | |
| Existing Scenario | |
| 12 numbers of T5 lamps were identified during the energy audit field survey in the facility. During discussion with staffs it is observed that the average utility of these fittings are of 80%. | |
| Proposed System | |
| The existing T5 may be replaced to LED tube of 18 W in phased manner and the savings will be of 36 % (inclusive of improved light output and reduced energy consumption) | |
| Financial Analysis | |
| Annual working hours (hr) | 2400 |
| No of fittings | 12 |
| Total load (kW) | 0.66 |
| Annual Energy Consumption (kWh) | 792 |
| Expected Annual Energy saving for replacing all fittings (kWh) | 531 |
| Cost of Power | 10.5<br>0 |
| Annual saving in Lakhs Rs (1st year) | 0.06 |
| Investment required for complete replacements [@Rs 450 per fittings](Lakhs Rs) | 0.05 |
| Simple Pay Back (in Months) | 11.6<br>3 |

| OTTOTRACTIONS- ENERGY AUDIT | |
|---|---|
| Energy Saving in Lighting by replacing existing 620 No's CFL Lamps to 9W LED Bulbs | |
| Existing Scenario | |
| 620 numbers of CFL were identified during the energy audit field survey in the facility. During discussion with staffs it is observed that the average utility of these fittings are of 80%. | |
| Proposed System | |
| The existing CFL may be replaced to LED bulbs of 9 W in phased manner and the savings will be of 70 % (inclusive of improved light output and reduced energy consumption) | |
| Financial Analysis | |
| Annual working hours (hr) | 2400 |
| No of fittings | 620 |
| Total load (kW) | 34.10 |
| Annual Energy Consumption (kWh) | 40920 |
| Expected Annual Energy saving for replacing all fittings (kWh) | 27416 |
| Cost of Power | 10.50 |
| Annual saving in Lakhs Rs (1st year) | 2.88 |
| Investment required for complete replacements [@Rs 150 per fittings](Lakhs Rs) | 0.93 |
| Simple Pay Back (in Months) | 3.88 |

| OTTOTRACTIONS- ENERGY AUDIT | |
|---|---|
| Energy Saving by replacing existing 770 No's in-efficient ceiling fans with Energy Efficient Five star fans | |
| Existing Scenario | |
| There are 770 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 30% with higher service value (air delivery/watt). | |
| Financial Analysis | |
| Annual working hours (hrs) | 2400 |
| Total numbers of ordinary fans | 770 |
| Total load (kW) | 61.60 |
| Annual Energy Consumption (kWh) | 73920 |
| Expected Annual Energy saving, for total replacement(kWh) | 22176 |
| Cost of Power (Rs) | 10.50 |
| Annual saving in Lakhs Rs (1st year) | 2.33 |
| Investment required for a total replacement (Lakhs Rs)[@1500 Rs per Fan with 50W at full speed] | 11.55 |
| Simple Pay Back (in Months) | 59.52 |

| OTTOTRACTIONS- ENERGY AUDIT | |
|---|---|
| **Installation of 10 kW Solar Power Plant (proposed)** | |
| **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 10 kW 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) | 10 |
| Total average kWh per day expected (3.5kWh/day average) | 35.00 |
| Total annual Generating Capacity (kWh) | 12775 |
| Cost of energy generated annually Lakhs Rs | 1.66 |
| Investment required (INR lakh)(Approx) | 7.50 |
| Simple Pay Back (in Months) lakh Rs | 54.19 |
| Life cycle in Yrs | 25 |
| Total Saving in Life Cycle (Approx) Rs Lakh | 41.52 |

# 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 | 144.16 |
| 2 | Carbon Sequestered tCO2e/yr | 1.87 |
| 3 | Carbon mitigated by Renewable Energy tCO2e/yr | 153.82 |
| 4 | Carbon mitigated by Energy Efficiency (Proposed) tCO2e/yr | 51.49 |
| 5 | Carbon mitigated by solar power plant (Proposed) (10 kWp) | 9.33 |
| 6 | Effective Carbon footprint tCO2e/yr | -72.34 |
| 7 | Total No of Students | 651 |
| 8 | Specific Carbon Footprint kg CO2e/Student/Yr | **-111.12** |

From this study it was found that carbon footprint of the campus to be -111.12 kg$CO_2$e/ student/ Year in place of current footprint ie. -17.70 kg$CO_2$e/ student/ Year. This will be achieved after implementing energy efficiency projects and implementation of additional 10kWp solar power plant.

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