Environmental and Green Audit Report

of

CHAUDHARI ATTARSINGH YADAV MEMORIAL EDUCATION TRUST'S

SIDDHANT COLLEGE OF ENGINEERING

Chakan-Talegaon Road, Near Chakan Auto Hub, Sudumbare,
Dist.Pune – 412109

Auditing Agency –
Prathamesh Energy Solution,
A-302, Shiv Unnati Residency,
Kalepadal, Hadapsar
Pune- 411 028

Prathamesh Energy Solution
A-302, Shiv Unnati residency, Kalepadal, Hadapsar, Pune-411028

Ref: PES/SCoE/2022-23/19

Date:

To,

The Principal
Siddhant College of Engineering
Chakan-Talegaon Road,
Sudumbare, Dist.Pune – 412109

Sub: Submission of Report on Environmental and Green Audit of College Campus

Respected Sir,

Please find enclosed herewith the report

Thanking you
Yours faithfully

For Prathamesh Energy Solution

Authorized Signatory

Prathamesh Energy Solution

A-302, Shiv Unnati Residency, Kalepadal, Hadapsar, Pune 411028

Ref: EC/SCoE /22-23/15

CERTIFICATE

This is to certify that we have conducted Environmental and Green Audit at **Siddhant College of Engineering, Chakan-Talegaon Road, Sudumbare, Dist. Pune,** in the Academic year 2022-23

. The College has adopted following Energy Efficient practices:

- Usage of Energy Efficient LED Fittings
- Maximum usage of Day Lighting
- Installation of Roof Top Solar PV Plant.
- Green Campus
- Rain water Harvesting system

We appreciate the support of Management, involvement of faculty members and students in the process of making the Campus Energy Efficient.

For,

Prathamesh Energy Solution,

M/s. Prathamesh Energy Solution Pune

Certificate of Registration

This is to Certify that
Environmental Management System of

PRATHAMESH ENERGY SOLUTION

A-302, SHIV UNNATI RESIDENCY, KALEPADAL, HADAPSAR, PUNE-411028, MAHARASHTRA, INDIA.

has been assessed and found to conform to the requirements of

ISO 14001:2015

for the following scope :

CONSULTANCY SERVICES FOR ENERGY AUDIT, GREEN AUDIT AND ENVIRONMENTAL AUDIT IN EDUCATIONAL INSTITUTIONS AND OTHER ORGANIZATIONS & SUBMISSION OF AUDIT CERTIFICATE AND REPORT.

Certificate No	: **23EELA98**		
Initial Registration Date	: 09/06/2023	Issuance Date	: 09/06/2023
Date of Expiry	: 08/06/2026		
1st Surve. Due	: 09/05/2024	2nd Surve. Due	: 09/05/2025

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Confederation of Indian Industry

The Indian Green Building Council

hereby certifies that

Vaijanath Narharirao Raibhole

has successfully demonstrated knowledge on the Green Building Design & Construction, Building Standards & Codes, IGBC Resources & Processes and Green Design Strategies & their Impacts, required to be awarded the title of

IGBC Accredited Professional

K S Venkatagiri
Executive Director
CII-Godrej GBC

V Suresh
Chairman
Indian Green Building Council

Gurmit Singh Arora
Vice-Chairman
Indian Green Building Council

200413

05 September 2020

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ACKNOWLEDGEMENT

We at Prathamesh Energy Solution, Pune, express our sincere gratitude to the management and Principal of Siddhant College of Engineering, Pune for awarding us the assignment of Green and Environmenta Audit of their College campus located at Chakan-Talegaon Road, Sudumbare, Dist. Pune

We are very much thankful to

- **Hon'ble Rajendra Singh Yadav, Founder, President, Siddhant Group of Institutes (SGI), Sudumbare, Pune**
- **Hon'ble Siddhant Yadav, Vice President, SGI, Sudumbare, Pune**
- **Hon'ble Mihir Yadav, Vice President, SGI, Sudumbare, Pune**
- **Dr. L.V. Kamble, Principal, Siddhant CoE, Pune**
- **Dr. P. A. Makasare. HOD, Mechanical Engineering Department, Siddhant CoE, Pune**

for giving us opportunity to conduct detailed energy audit of the institute and provide all the required data and information promptly for the smooth conduction of detailed energy and green audit.

We are also thankful to various Heads of Departments, IQAC Coordinator & other Staff members for helping us during the field measurements.

We are also thankful to all the technical staff and office staff for helping during the measurements at the electrical distribution center.

EXECUTIVE SUMMARY

After the Field measurements & analysis, we present herewith important observations made and various measures to reduce the Energy Consumption & mitigate the CO_2 emissions.

1. Siddhant College of Engineering, Pune, consumes electrical Energy in majority used for various gadgets & office operations.

2. The various projects already implemented by the College are

- Installed solar roof top plant of capacity 221kWp on the campus building roof. At present solar roof top is with net metering and it is meeting requirement of electricity demand of college campus buildings in the premises.
- Usage of natural day lights and natural air circulation
- Usage of Natural Day light in corridors specifically
- Usage of LED lighting for Admin & outdoor lighting
- Initiatives for plastic free campus

3. Important Parameters: Electrical Energy:

Electricity is used for different purposes and at different sections in the college campus. The details of electricity distribution as mentioned below.

Sr. No.	Consumer No.	Electrical Meter No.	Location/Purpose	Payee
1	181029037080	055-XE474326	College building/building operation	M/S. CHAUDHARI ATTARSINGH YADAV MEMO.EDU.TRUST

The important parameters of electrical consumption as per Consumer no. in the campus are mentioned as below.

Sr. No	Consumer No.	Parameter	Max	Min	Average
1	181029037080	Units consumed, kWh	21502	2284	5458.5
		Electricity Bill amount	358940	105977	149911.2
		Total average units consumed per month, kVAh			5458.5

4. Important Parameters: CO_2 Emissions (Average, MT/Annum)

No	Consumer No.	Particulars	Value MT
1	181029037080	CO_2- Emissions- Electricity Usage	52.40
		Total	52.40

On the basis of average electricity consumption CO_2 emission is 52.40MT /annum. In addition to this LPG is being consumed for canteen for food preparation. Nearly LPG consumption annually is 300 commercial cylinders i.e. 900 kg/annum. On the basis of average LPG usage CO_2 emission is 0.9MT/annum.

5. Benchmark: In terms of Electrical Energy & CO_2 emissions:

We now present two important benchmarks in respect of Electrical Energy consumption & CO_2 emissions as under.

No	Particulars	Value	Unit
1	Electrical Energy consumed	**0.031**	kVAh/sq. ft.
3	CO_2- Emissions	**0.29**	Kg per annum /sq. ft.

6. Recommendations:

We present herewith various proposals to reduce the Electrical Energy demand and reduce the CO_2 emissions

No	Recommendation	Annual saving potential in kWh /Kg of LPG	Annual Saving Potential in MT of CO_2	Annual monetary gain, Rs.
1	Installation of 50kW Solar PV roof top on college building	84000 kWh	67.2	840000
2	Solar street lights	262.8 kWh	0.21	2628
3	Solar powered light for hoarding	-	-	-
4	Solar charging stations	-	-	-
	Total	**84262.8**	**67.41**	**842628**

Notes & assumptions:

1. 1 Unit of Electrical Energy releases 0.8 Kg of CO_2 into atmosphere
2. 1 Kg of LPG releases 3 Kg of CO_2 into atmosphere

3. Daily working hours-10
4. Annual working Days-280
5. Average Rate of Electrical Energy- Rs 10 per kWh

ABBREVIATIONS

DP	:	Double Pole
CFL	:	Compact Fluorescent Lamp
EESL	:	Energy Efficiency Services Limited
F P	:	Feeder Pillar
MSEDCL	:	Maharashtra State Electricity Distribution Company Ltd.
MEDA	:	Maharashtra Energy Development Agency
MIDC	:	Maharashtra Industrial Development Corporation
V	:	Voltage
I	:	Current
kW	:	kilo-Watt
kVA	:	Apparent Power
kVAr	:	Reactive Power
P F	:	Power Factor
kWp	:	Kilo Watt peak

CHAPTER-I
ENVIRONMENT AND GREEN AUDIT: INTRODUCTION

1.1 Objectives:

1. To Study tree plantation in college campus
2. To Study the present CO_2 emissions
3. To study Scope for usage of Renewable Energy
4. To study various measures for sustainable development

1.2 General Details of Siddhant College of Engineering, Pune:

No	Head	Particulars
1	Name of Institution	Siddhant College of Engineering, Pune
2	Address	Chakan-Talegaon Road, Sudumbare, Dist.Pune – 412109
3	Year of Establishment	2005
4	Salient Features	Affiliated to Savitribai Phule Pune University
4	Courses offered	UG courses in Civil Engineering, Computer Engineering, Information technology, Electronics and Telecommunications, Mechanical Engineering PG Courses in Computer Engineering, Information technology, Electronics and telecommunications-VLSI & Embedded system, Mechanical-Design engineering
5	No of Students	1288
6	Total built up area	177066.33 Sq. ft.

CHAPTER-II
GREEN AUDIT FOR AY-2022-23

Siddhant College of Engineering, Pune is one of the leading higher technical educational Institutions of Pune under Savitribai Phule Pune University, Pune. It has been providing quality technical education to the students in various professional courses. The College is having beautiful green campus and a highly greenery maintenance college in Pune. The college has been accredited by National Assessment and Accreditation Council (NAAC), Bangalore.

We have prepared a green audit report after visiting the college campus by our team. This green audit report is based on the following major points.

1. Plantation in the campus
2. Carbon accounting
3. Use of Renewable energy options for saving the environment
4. Illumination in class rooms
5. Water audit and Rainwater Harvesting
6. Waste disposal

1. Plantation in the campus

Plantation is playing very important role in the green audit and helping to save environment from damage. The campus plantation is very diverse and well maintained.

The different species are cultivated to increase greenery of the campus. The species included Trees, Shrubs, Herbs, Climbers, ornamentals etc.

There are 536 trees and shrubs present inside Siddhant College of Engineering, Pune campus. After a daylong survey and records about the plantation in the campus is prepared which is as per following table.

Sr. No.	Name of Tree	Quantity
1	Areka pam	40
2	Ashok Tree	130
3	MorPhanki	15
4	Botal Pam	40
5	Naral	30
6	Jasvandi	35
7	Gulab	10
8	Dalimb	1
9	Limb	5
10	Krismus	8
11	Kardal	8
12	Mogra	20
13	Hamoliya Petarse	3
14	Yasian Pam	9
15	Ardhisupari	30
16	Welping Fig	4
17	Ratrani	10
18	Fleush	3
19	Pivla Chafa	5
20	Pandra Chafa	2

21	Kadipata	1
22	Chaha Pati	1
23	Tea Plate	1
24	Visual Matches	5
25	Song of India	2
26	Safed Jambul	6
27	Phanas	3
28	Sitaphal	1
29	Ruee	2
30	Amba	5
31	Kaju	2
32	Tibuti	4
33	Idlimbu	6
34	Chiku	4
35	Saru	5
36	Ravlipa	75
37	Garden Quater	5

Photo-1: Garden view of Siddhant College of Engineering, Pune

Photo-2: Front Plantation view of Siddhant College of Engineering, Pune

Photo-3: Tree Plantation at Siddhant College of Engineering, Pune

Photo-4: Lawn at Siddhant College of Engineering, Pune

1.1 Calculation of amount of CO_2 sequestered in trees per year

The carbon sequestration potential of the plant species present in green belt has been estimated and suitable plant with maximum sequestration of CO_2 was recommended. Carbon sequestration is nothing but capturing atmospheric carbon dioxide or anthropogenic CO_2 from large scale stationary sources like cement industry before it is released to the atmosphere. Once captured, the CO_2 gas is put into long term storage. CO_2 sequestration in plants has the potential to significantly reduce the level of carbon that occurs in the atmosphere. Terrestrial or biologic sequestration means using plants to capture CO_2 from the atmosphere and then storing it as carbon in the stems and roots of the plants as well as in the soil. The green belts in industrial area acts as sink for capturing and storing carbon dioxide released from the industries.

Assessment of carbon sequestration ability of trees for adopting in greenbelt of cement industries

The carbon dioxide sequestered in plant species are determined based on following method:

1. Determine the total (green) weight of the tree
2. Determine the dry weight of the tree
3. Determine the weight of carbon in the tree
4. Determine the weight of carbon dioxide sequestered in the tree
5. Determine the weight of CO_2 sequestered in the tree per year

1.2 Determination of Total (Green) Weight of the Tree

The algorithm to calculate the weight of a tree is:

For trees with D < 11: $W = 0.25D^2H$

For trees with D >= 11: $W = 0.15D^2H$

Where, W = Above-ground weight of the tree in pounds

D = Diameter of the trunk in inches

H = Height of the tree in feet

Depending on the species, the coefficient (e.g. 0.25) could change and the variables D^2 and H could be raised to exponents just above or below 1. However, these two equations could be seen as an “average” of all the species’ equations. The root system weighs about 20% as much as the above-ground weight of the tree. Therefore, to determine the total green weight of the tree, multiply the above-ground weight of the tree by 120%.

1.3 Determination of Dry Weight of the Tree

Taking all species in into account, the average tree is 72.5% dry matter and 27.5% moisture.

Therefore, to determine the dry weight of the tree, multiply the weight of the tree by 72.5%.

1.4 Determine the weight of carbon in the tree

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

Assessment of carbon sequestration ability of trees for adopting in greenbelt of cement industries

Determine the weight of carbon dioxide sequestered in the tree

CO_2 is composed of one molecule of Carbon and 2 molecules of Oxygen.

The atomic weight of Carbon is 12.001115.

The atomic weight of Oxygen is 15.9994.

The weight of CO_2 is C+2*O=43.999915.

The ratio of CO_2 to C is 43.999915/12.001115=3.6663.

Therefore, to determine the weight of carbon dioxide sequestered in the tree, multiply the weight of carbon in the tree by 3.6663
Determine the weight of CO_2 sequestered in the tree per year
Divided the weight of carbon dioxide sequestered in the tree by the age of the tree.

2. Carbon Accounting

A Carbon Foot print is defined as the Total Greenhouse Gas emissions, emitted due to various activities.

In this we compute the emissions of Carbon-Di-Oxide, by usage of the various forms of Energy used by the College for performing its day to day activities. The college uses electrical energy for operating various electrical gadgets.

We herewith furnish the details of electrical Energy consumption consumer number wise as under

4.1 Month wise Consumption of Electrical Energy: 181029037080

Sr. No	Month	kVAh
1	May-23	21502
2	April-23	3805
3	March-23	5313
4	Feb-23	9228
5	Jan-23	4636
6	Dec-22	4816
7	Nov-22	3337
8	Oct-22	2712
9	Sep-22	2576
10	Aug-22	2284
11	July-22	2325
12	June-22	2968
13	Total	65502
14	Average	5458.5
15	Max	21502
16	Min	2284

4.2 Basis for computation of CO_2 Emissions:

The basis of Calculation for CO_2 emissions due to Electrical Energy are as under

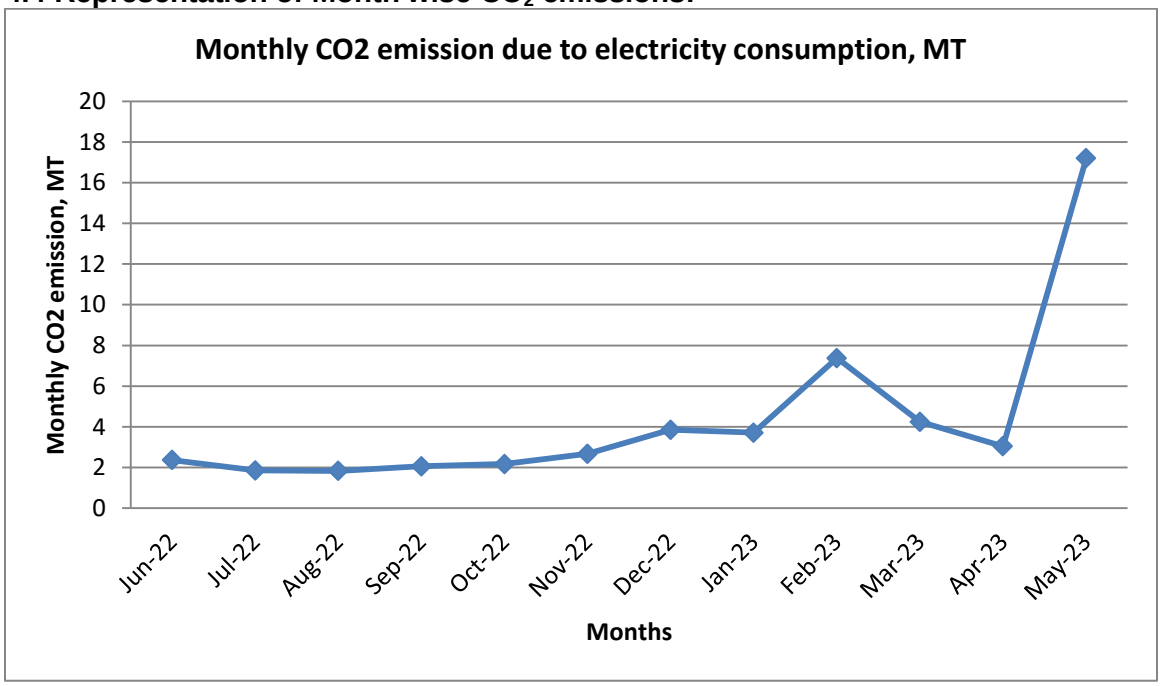
- 1 Unit (kWh) of Electrical Energy releases **0.8 Kg of CO_2** into atmosphere

Based on the above Data we compute the CO_2 emissions which are being released in to the atmosphere by the College due to its Day to Day operations.

4.3 Month wise CO2 Emissions: 181029037080

Sr. No	Month	Electrical Energy Consumed, kVAh	CO2 Emissions due to Electricity, MT
1	May-23	21502	17.20
2	April-23	3805	3.04
3	March-23	5313	4.25
4	Feb-23	9228	7.38
5	Jan-23	4636	3.71
6	Dec-22	4816	3.85
7	Nov-22	3337	2.67
8	Oct-22	2712	2.17
9	Sep-22	2576	2.06
10	Aug-22	2284	1.83
11	July-22	2325	1.86
12	June-22	2968	2.37
13	Total	65502	52.40
14	Average	5458.5	4.37
15	Max	21502	17.20
16	Min	2284	1.83

4.4 Representation of Month wise CO_2 emissions:



4.5 Benchmarking:

Now we compute the CO2 emissions per sq. ft. basis as under:

No	Parameter	Value	Unit
1	CO2 emissions	52.40	MT/annum
2	College area	177066.33	Sq. ft.
3	**CO2 emissions/sq. ft.**	**0.29**	**Kg of CO_2 per annum/sq. ft.**

3. Use of Renewable energy options for saving the environment

3.1 Installation of 221 kWp Solar PV Power Plant:

Solar roof top power plant having capacity 221 kWp is installed on Siddhant Pharmacy College building and Siddhant School building, at college campus which meets the requirement of electricity demand of these buildings. The Solar roof top plant is successfully installed and it is in operation to meet the requirement of electricity of institute campus building. The existing solar roof top installed technical specifications and details are given below.

Technical Specifications:

Siddhant College of Engineering, Pune has installed solar roof top power plant. The brief specifications and details of the plant are mentioned below.

- **System Capacity:** 221 kW
- **PV Module:** Navitas Solar, 325 Wp Polycrystalline – 680 nos.
- **Output:** 5.5 kWh/Sq.m/day (All output is under STC, 25°C)
- **Inverter**: Growatt- 30kWp-6 Inverters

Photo-5: 221 kW solar roof top on Siddhant School building roof.

3.2 Solar powered light for hoarding

Lighting solar systems are the fixed installations designed for domestic as well as small scale commercial application. The component of the solar lighting system includes solar PV module (solar cells), charge

controller, solar battery and lighting system (lamps & fans). Modules are installed in the open on roof/terrace - exposed to sunlight and the charge controller and battery are kept inside a protected place in the house.

Figure-1: Solar powered light for Hoarding

This system comes with multiple benefits such as:

- **Economical:** Since the sun provides energy free of charge, 30% power savings on the electricity bill can be availed with longer back up lighting system at zero running cost.
- **Non-Polluting:** Powered by the sun's renewable energy, the system is energy neutral and an absolutely clean source of illumination. 1kWp solar installation reduces 1⁄2 ton of CO_2 (carbon dioxide) per annum.
- **No Maintenance:** The system has few moveable parts – reducing the risk of breakage. Once installed, it lasts for long time and requires little attention.

This system can be used to power the huge hoardings in the college campus.

Solar powered hoarding lighting system proposed will provide a better, faster, cheaper (and cleaner) alternative with solar. Since this product competes with diesel or conventional fuels, we needed to ensure we beat the cost of a diesel solution. In order to achieve that with solar, we consider the following system:

1. Highly Efficient Solar Panel

2. Charge Controllers with MPPT Technology – increases solar electricity production by up to 30% compared to conventional charge controllers

3. LED Projection Light – consumes 10-times less electricity compared to conventional bulbs, and has a 50,000 hour warranty.

Features:

- Auto on off
- 4 Days Battery Back Up
- Robust housing
- Weather proof

With this entire put together, we ended up with systems that provide 6 hours of lighting each night with 4 -lamp system to light up boards up to 15′x30′, and a 8-lamp system to light larger boards up to 20′x40′.More importantly, with these options, payback of the system will come around 2.5 years. This system provides a way to reduce the lightings costs, get rid of all the operational hassles of owning a diesel generator, plus brand benefits from being “green” with the use of renewable energy like solar powered light hoarding board.

3.3 Solar charging stations

Solar cell phone chargers use solar panels to charge cell phone batteries. They are an alternative to conventional electrical cell phone chargers and in some cases can be plugged into an electrical outlet. Solar mobile charger is a device which can charge mobile phones using solar radiation. Its major component is a compact solar panel. This solar panel traps solar energy and produces an output voltage. But, since the light radiations falling on the solar panel can vary, the output voltage becomes unstable. For charging a mobile phone, stable voltage is required. So, to make the output voltage stable and regulated, voltage regulator circuit along with the solar panel is used.

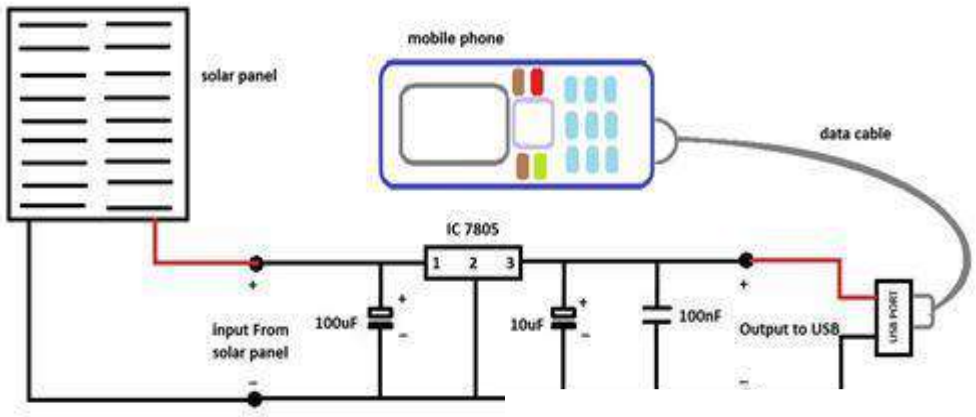


Figure-2: Solar charging Stations

Most of the mobile phones have computer connectivity via USB cable. USB port establishes 4 connection terminals. The connection terminals at the two extreme ends are the supply terminals. In a female USB connector (port via which we plug in USB devices to computer), these terminals carry 5V DC. When a mobile phone is connected to the USB port of a computer, it utilizes this 5V supply to recharge battery. This feature is used in a solar mobile charger. It converts and regulates solar energy to 5V DC and the output will be available through the female USB connector. To this connector, we can easily connect a mobile phone via data cable.

3.4 Installation of 50 kWp Solar PV roof Top on Siddhant College of Engineering, building:

During the Audit, it was revealed that the College has space on the Terrace. It is proposed to install a Solar Photovoltaic roof top with net meter of capacity **50 kWp.** The system will cater the Day load Demand of the College.

We furnish herewith the saving potential as under

No	Particulars	Value	Unit
1	Installed Capacity of Solar PV Pack	50	kWp
2	Daily working period	6	Hrs./Day
3	Daily units generated	300	kWh/Day
4	Annual working days	280	Day/annum
5	Annual saving in Grid Electrical Energy	84000	kWh/annum
6	Annual CO_2 saving potential	67.2	MT/Annum
7	Present Energy Charges	10	Rs/kWh
8	Annual monetary Gain	840000	Rs/Annum
9	Investment required	22,50000	Rs lump sum
10	Payback period	2.67	Years

4. Illumination in class rooms

Lighting puts a huge impact on the visibility and appearance of every space. Sufficient and beautiful lighting can enhance the look of a dull space, whereas improper lighting implementations can make a catchy area look less impressive. Poor lighting at work can lead to eye-strain, fatigue, headaches, stress and accidents. On the other hand, too much light can also cause safety and health problems such as “glare” headaches and stress. Siddhant College of Engineering, Pune is using daylight effectively, specifically at corridors. The typical class room illumination in lux is mentioned as below.

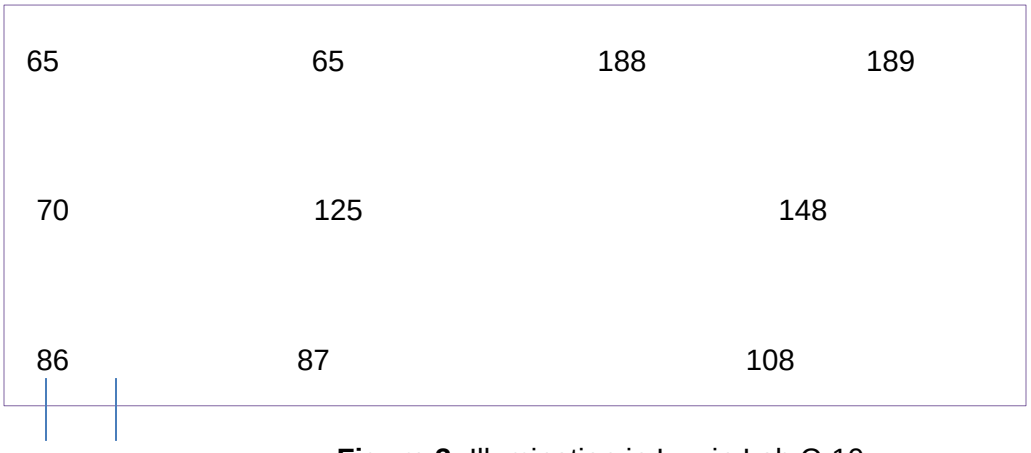


Figure 3: Illumination in Lux in Lab C-10

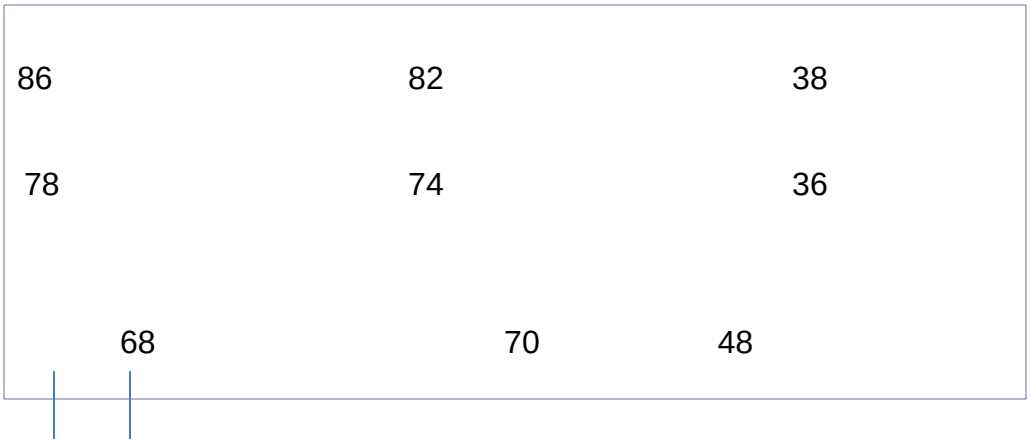


Figure 4: Illumination in Lux in Class room A-13

5. Water Audit and Rain water harvesting

A water crisis is a very sensitive issue these days all over the world. Recently we are facing water crisis in major part of Maharashtra like Marathwada, Khandesh, Pachim Maharashtra and North Maharashtra. Siddhant College of Engineering, Pune has taken a good initiative for maintaining greenery in the campus and less concrete zone, it means that college campus is allowing the rainwater to absorb under the ground and maintain the underground water level. Siddhant college of Engineering, Pune provides drinking water through RO filter and water coolers.

In addition to this as per the survey and site location following activities can be implemented for the conservation of water.

5.1 Water storage and consumption

Siddhant College of Engineering, Pune campus is having water supply through well located in the campus to mitigate the need of requirement water for various activities. The college campus has temporary water storage capacities in terms of overhead tanks on the Institute building. Water is temporarily stored in the campus for various activities. There is a provision of sparkler system to supply the water in garden to maintain greenery. The details of water storage in the campus as mentioned below.

Tank type	For Regular Use (ltr)	Qty	For Fire Use (ltr)
overhead	5000	2	Nil
overhead	500	1	Nil

5.2. Rain water harvesting

The system of rain water harvesting is an integral part of any educational institution. This system helps to conserve the rain water and also to use during the time of its desirable. This system helps the students to understand the basic concepts of rainwater harvesting system and their effective use in the real life.

Already Siddhant College of Engineering, Pune have provisions of collection of gray rain water from all the building taken through some specific path and charged in the ground below building to maintain the ground level water. It is suggested to charge the rain water through ring well in the campus.

Photo-6: View rain water collection from building

Advantages of rain water harvesting

(a) Promotes adequacy of underground water

(b) Mitigates the effect of drought

(c) Reduces soil erosion as surface run-off is reduced

(d) Decreases load on storm water disposal system

(e) Reduces flood hazards

(f) Improves ground water quality / decreases salinity

(by dilution)

(g) Prevents ingress of sea water in subsurface aquifers in coastal areas

(h) Improves ground water table, thus saving energy (to lift water)

(i) The cost of recharging subsurface aquifer is lower than surface reservoirs

(j) The subsurface aquifer also serves as storage and distribution system

(k) No land is wasted for storage purpose and no population displacement is involved

(l) Storing water underground is environment friendly

Rain water harvesting potential

The total amount of water that is received in the form of rainfall over an area is called the rain water endowment of that area. Out of this, the amount that can be effectively harvested is called rain water harvesting potential.

All the water which is falling over an area cannot be effectively harvested, due to various losses on account of evaporation, spillage etc. Because of these factors the quantity of rain water which can effectively be harvested is always less than the rain water endowment. The collection efficiency is mainly dependent on factors like runoff coefficient and first flush wastage etc. Runoff is the term applied to the water that flows away from catchments after falling on its surface in the form of rain.

Runoff depends upon the area and type of catchment over which it falls as well as surface features. Runoff can be generated from both paved and unpaved catchment areas. Paved surfaces have a greater capacity of retaining water on the surface and runoff from unpaved surface is less in comparison to paved surface. In all calculations for runoff estimation, runoff coefficient is used to account for losses due to spillage, leakage, infiltrations catchment surface wetting and evaporation, which will ultimately result into reduced runoff. Runoff coefficient for any catchment is the ratio of the volume of water that run off a surface to the total volume of rainfall on the surface. The runoff coefficient for various surfaces is given in following table.

Sr. No.	Type of catchment	Coefficient
1	**Roof Catchments**	
	Tiles	0.8-0.9
	Corrugated metal sheets	0.7-0.9
2	**Ground surface coverings**	
	Concrete	0.6-0.8
	Brick pavement	0.5-0.6
3	**Untreated ground catchments**	
	Soil on slopes less than 10%	0.0-0.3
	Rocky natural catchments	0.2-0.5

Based on the above factors, the water harvesting potential of site could be estimated using the following equation:

Rain Water harvesting potential = Amount of Rainfall x area of catchment x Runoff coefficient

Rain water harvesting methods

(a) Storing rain water for direct use

(b) Recharging ground water aquifers, from roof top run off

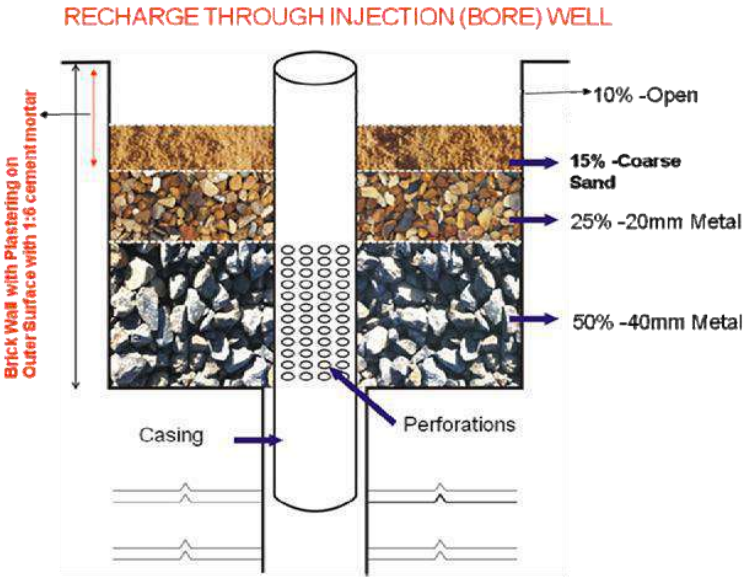
(c) Recharging ground water aquifers with runoff from ground area

According to the site of Siddhant College of Engineering, Pune campus the method of recharging ground water aquifiers from roof top run off may be suitable.

Recharging ground water aquifers from roof top run off

Rain water that is collected on the roof top of the building may be diverted by drain pipes to a filtration tank (for bore well, through settlement tank) from which it flows into

the recharge well, as shown in following Figure. The recharge well should preferably be shallower than the water table. This method of rain water harvesting is preferable in the areas where the rainfall occurs only for a short period in a year and water table is at a shallow depth. The schematic diagram of recharging water aquifers from roof top run off is as follows.



6. Waste disposal

The present Prime Minister of India, Shri Narendra Modiji launched " Swach Bharat Abhiyan" (Clean India Mission), on 2nd October, 2014. In this mission, the proper use of dustbins is one of the major priorities. For the successful implementation of this mission collective mass effort is necessary. The higher education institutions like Siddhant College of Engineering, Pune need to play a major role in this regard to keep their campus neat and clean. Proper use of dustbins is not only the solution for the generating garbage in the college campus. Now a days, its proper treatment should be given a major priority.

Characteristic and Disposal Practices of Solid Wastes Waste Management

Sr. No.	Waste Category	Method of disposal
1	Solid waste from trees droppings and lawn	Vermi Composting Organic Manure
2	Canteen waste	Vermi Composting Organic Manure
3	Plastic waste	Through Authorized recycler after segregation
4	Solid Waste from Lab	Solid Waste from Lab
5	Chemical waste generated in chemistry	The college is need to have a very good practice to use dilute chemicals for the experimentation in these labs. These dilute chemicals can be further diluted and disposed in the pit near the lab.
6	E-waste and defective items from computer and electronics lab	The institution has to decide to contact approved E- waste management and Disposal facility in order to dispose E-waste in scientific manner.

7	Sanitary Napkins	The institution have to take a very good initiative to install sanitary napkin disposal machine at the different location in the college campus. It is suggested to install vending machine along with incinerators at required locations in the college campus.

6.1 Vermiculture Composting Culture

Vermicomposting is basically a managed process of worms digesting organic matter to transform the material into a beneficial soil amendment. The main purpose of this is to reduce disposable waste in the college campus and after complete process of vermi composting it is used as manure for plantation and greenery in the campus. It is also used for the demonstration and awareness in farmers to implement organic farming and its importance.

The main benefits of the process are to reduce the waste in the environment and utilized for some useful purpose and also it is cost savings process.

The earthworms being voracious eaters consume the biodegradable matter and give out a part of the matter as excreta or vermi-castings. The vermi-casting containing nutrients is a rich manure for the plants. Vermicompost, apart from supplying nutrients and growth enhancing hormones to plants, improves the soil structure leading to increase in water and nutrient holding capacities of soil. Fruits, flowers and vegetables and other plant products grown using vermicompost are reported to have better keeping quality. A growing number of individuals and institutions are taking interest in the production of vermicompost utilizing earthworm activity. As the operational cost of production of this compost works out to less than ` Rs. 2.0/Kg., it is quite profitable to sell the compost even at Rs. 4.00 to 4.50/Kg.

Process:

The process of composting crop residues / agri wastes using earthworms comprise spreading the agricultural wastes and cow dung in gradually built up shallow layers. The pits are kept shallow to avoid heat built-up that could kill earthworms. To enable earthworms to transform the material relatively faster a temperature of around 30^0C is maintained. The final product generated by this process is called vermicompost which essentially consist of the casts made by earthworms eating the raw organic materials. The process consists of constructing brick lined beds generally of 0.9 to 1.5 m width and 0.25 to 0.3 m height are constructed inside a shed open from all sides. For commercial production, the beds can be prepared with 15 m length, 1.5 m width and 0.6 m height spread equally below and above the ground. While the length of the beds can be made as per convenience, the width and height cannot be increased as an increased width affects the ease of operation and an increased height on conversion rate due to heat built up.

Cow dung and farm waste can be placed in layers to make a heap of about 0.6 to 0.9 m height. Earthworms are introduced in between the layers @ 350 worms per m3 of bed volume that weighs nearly 1 Kg. The beds are maintained at about 40-50% moisture content and a temperature of 20–30^0 C by sprinkling water over the beds. When the commercial scale production is aimed at, in addition to the cost of production, considerable amount has to be

invested initially on capital items. The capital cost may work out to about Rs. 5000 to 6000 for every tonne of vermicompost production capacity. The high unit capital cost is due to the fact that large units require considerable expenditure on preparation of vermi beds, shed to provide shelter to these beds and machinery. However these expenditures are incurred only once.

Under the operational cost, transportation of raw materials as also the finished product are the key activities. When the source organic wastes and dung are away from the production facility and the finished product requires transportation to far off places before being marketed, the operational cost would increase. However, in most of the cases, the activity is viable and bankable. Following are the items required to be considered while setting up a unit for production of vermi-compost.

Components of a Commercial Unit

Commercial units have to be developed based on availability of cow dung locally. If some big dairy is functioning then such unit will be an associated activity. Commercial units must not be designed based on imported cow dung.

1. Sheds

For a vermi-composting unit, whether small or big, this is an essential item and is required for securing the vermi beds. They could be of attached roof supported by bamboo rafters or steel trusses. Locally available roofing materials or HDPE sheet may also be used in roofing to keep the capital investment at reasonably lower level. If the size is so chosen as to prevent wetting of beds due to rain on a windy day, they could be open sheds. While designing the sheds adequate room/pathways has to be left around the beds for easy movement of the labourers attending to the filling and harvesting the beds.

2. Vermi-beds

Normally the beds have 0.3 to 0.6 m height depending on the provision for drainage of excess water. Care should be taken to make the bed with uniform height over the entire width to avoid low production owing to low bed volumes. The bed width should not be more than 1.5 m to allow easy access to the center of the bed.

3. Fencing and Roads/Paths

The site area needs development for construction of structures and development of roads and pathways for easy movement of hand-drawn trolleys/wheel barrows for conveying the raw material and the finished products to and from the vermi-sheds. The entire area has to be fenced to prevent trespass by animals and other unwanted elements. These could be estimated based on the length of the periphery of the farm and the length and type of roads/paths required. The costs on fencing and formation of roads should be kept low as these investments are essential for a production unit, yet would not lead to increase in production.

4. Water Supply System

As the beds have to be kept moist always with about 50% moisture content, there is a need to plan for a water source, lifting mechanism and a system of conveying and applying the water to the vermi-beds. Drippers with round the clock flow arrangement would be quite handy for continuous supply and saving on water. Such a water supply system requires considerable initial investment. However, it reduces the operational cost on hand watering and proves economical in the long run. The cost of these items would depend on the capacity of the unit and the type of water supply chosen.

5. Transportation

For any vermi-composting unit transport arrangement is a must. When the source of raw material is away from the production unit, an off-site transport becomes major item of investment. A large sized unit with about 1000 tonnes per annum capacity may require a three tonne capacity mini-truck. With small units particularly with the availability of raw material near the site, expending on transport facility may become infructuous. On-site transport facilities like manually drawn trolleys to convey raw material and finished products between the storage point and the vermi-compost sheds could also be included in the project cost.

Design calculations

The size of the bed can selected as per the space available and convenient to the customer. Brick lined beds generally of 0.9 to 1.5 m width and 0.25 to 0.3 m height are constructed inside a shed open from all sides. On the basis of site survey and suitability of operation lets consider following dimensions for the bed. Generally, earthworms are introduced in between the layers @ 350 worms per m3 of bed volume that weighs nearly 1 Kg.

L= 3 m

W = 1.5 m

H = 0.6 m

Volume of the bed = 2.7 m^3

$$Input = \frac{15\,kg\ of\ organic residue}{m3 \times 15\,days} = \frac{1\,kg\ of\ organic residue}{m3 \times 1\,day}$$

It means for 2.7 m^3, 270 kg of organic residue is required. Therefor for a month approximately 8100 kg (8.1 Ton) of organic residue is required.

The financial viability on the basis of available data of the vermicompost system is shown below.

Sr. No.	Particulars	Expenditure Cost (Rs.)
1	Bed construction	Already available 10,000/-
2	Fencing including roof	5000/-
3	Water Dripper	3000/-
4	Electrical connections	1000/-
5	Earthworms	1000/-
6	Salary & wages	20000/-
7	Sale of Vermicompost (@ Rs.100 /kg at 30% conversion)	121500/-
	Net Benefit	**81500/-**

Chapter III
SUGGESTIONS AND RECOMMENDATIONS

Following are the suggestions and actions on the basis of green and environmental audit are suggested to implement in the campus on the basis of funds availability and institute preferences.

Green Audit: Environment conservation opportunities:

- Plants/Trees in the college campus may be designated with botanical name and specific number on the basis of year of plantation. There will be brick arrangement at the bottom to supply water to the plant.
- Water management system must be in place. Reduction in water consumption by addressing leakages of taps and other miscellaneous utilities. Installation of flow meters which will help in reduction of water consumption. TOD can be implemented for pumping application.
- Rainwater harvesting pipe which collects rain water from respective building may have filter and properly charge the ground through ring well. Ring well can constructed near the rain water collection area, the approximate expenditure to construct the ring well will be @ Rs. 30,000/- per ring well.
- Provide firefighting system in the institute buildings. Also firefighting extinguishers at major places like electrical junction box, DG set room and Laboratories etc. required nos. of dustbins at respective locations in the college campus.
- Vermi-culture composting plant should be installed and the organic compost from the same will be either utilized for the plants/trees and maintaining greenery in the college campus or sell for organic farming.
- It is suggested to display Energy conservation slogans boards in the college campus and classroom to make awareness about importance of energy saving.

Energy Audit Report

of

CHAUDHARI ATTARSINGH YADAV MEMORIAL EDUCATION TRUST'S

SIDDHANT COLLEGE OF ENGINEERING

Chakan-Talegaon Road, Near Chakan Auto Hub, Sudumbare,
Dist.Pune – 412109

Auditing Agency –
Prathamesh Energy Solution,
A-302, Shiv Unnati Residency,
Kalepadal, Hadapsar
Pune- 411 028

Prathamesh Energy Solution
A-302, Shiv Unnati residency, Kalepadal, Hadapsar, Pune-411028

Ref: PES/SCoE/2022-23/15

Date:

To,

The Principal
Siddhant College of Engineering
Chakan-Talegaon Road,
Sudumbare, Dist.Pune – 412109

Sub: Submission of Report on Energy Audit of College Campus

Respected Sir,

Please find enclosed herewith the report

Thanking you
Yours faithfully

For Prathamesh Energy Solution

Authorized Signatory

Prathamesh Energy Solution

A-302, Shiv Unnati Residency, Kalepadal, Hadapsar, Pune 411028

Ref: PES/EEP/SCoE /22-23/11

CERTIFICATE

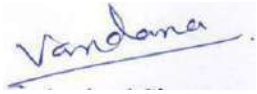
This is to certify that we have conducted Energy Audit at **Siddhant College of Engineering Chakan-Talegaon Road, Sudumbare, Dist. Pune – 412109**, in the Academic year 2022-23

.The College has adopted following Energy Efficient practices:

- Usage of Energy Efficient LED Fittings
- Maximum usage of Day Lighting
- Installation of Roof Top Solar PV Plant.
- Green Campus
- Rain water Harvesting system

We appreciate the support of Management, involvement of faculty members and students in the process of making the Campus Energy Efficient.

For,



Prathamesh Energy Solution,

Certificate of Registration

This is to Certify that
Quality Management System of

PRATHAMESH ENERGY SOLUTION

A-302, SHIV UNNATI RESIDENCY, KALEPADAL, HADAPSAR, PUNE-411028, MAHARASHTRA, INDIA.

has been assessed and found to conform to the requirements of

ISO 9001:2015

for the following scope :

CONSULTANCY SERVICES FOR ENERGY AUDIT, GREEN AUDIT AND ENVIRONMENTAL AUDIT IN EDUCATIONAL INSTITUTIONS AND OTHER ORGANIZATIONS & SUBMISSION OF AUDIT CERTIFICATE AND REPORT.

Certificate No	: **23EQMD10**		
Initial Registration Date	: 19/06/2023	Issuance Date	: 19/06/2023
Date of Expiry	: 18/06/2026		
1st Surve. Due	: 19/05/2024	2nd Surve. Due	: 19/05/2025

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Director

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ACKNOWLEDGEMENT

We at Prathamesh Energy Solution, Pune, express our sincere gratitude to the management and Principal of Siddhant College of Engineering, Pune for awarding us the assignment of Energy Audit of their College campus located at Chakan-Talegaon Road, Sudumbare, Dist. Pune

We are very much thankful to

- **Hon'ble Rajendra Singh Yadav, Founder, President, Siddhant Group of Institutes (SGI), Sudumbare, Pune**
- **Hon'ble Siddhant Yadav, Vice President, SGI, Sudumbare, Pune**
- **Hon'ble Mihir Yadav, Vice President, SGI, Sudumbare, Pune**
- **Dr. L.V. Kamble, Principal, Siddhant CoE, Pune**
- **Dr. P. A. Makasare. HOD, Mechanical Engineering Department, Siddhant CoE, Pune**

for giving us opportunity to conduct detailed energy audit of the institute and provide all the required data and information promptly for the smooth conduction of detailed energy and green audit.

We are also thankful to various Heads of Departments, IQAC Coordinator & other Staff members for helping us during the field measurements.

We are also thankful to all the technical staff and office staff for helping during the measurements at the electrical distribution center.

EXECUTIVE SUMMARY

After the Field measurements & analysis, we present herewith important observations made and various measures to reduce the Energy Consumption & mitigate the CO_2 emissions.

1. Siddhant College of Engineering, Pune, consumes electrical Energy in majority used for various gadgets & office operations.

2. The various projects already implemented by the College are

- Installed solar roof top plant of capacity 221kWp on the campus building roof. At present solar roof top is with net metering and it is meeting requirement of electricity demand of college campus buildings in the premises.
- Usage of natural day lights and natural air circulation
- Usage of Natural Day light in corridors specifically
- Usage of LED lighting for Admin & outdoor lighting
- Initiatives for plastic free campus

3. Important Parameters: Electrical Energy:

Electricity is used for different purposes and at different sections in the college campus. The details of electricity distribution as mentioned below.

Sr. No.	Consumer No.	Electrical Meter No.	Location/Purpose	Payee
1	181029037080	055-XE474326	College building/building operation	M/S. CHAUDHARI ATTARSINGH YADAV MEMO.EDU.TRUST

The important parameters of electrical consumption as per Consumer no. in the campus are mentioned as below.

Sr. No	Consumer No.	Parameter	Max	Min	Average
1	181029037080	Units consumed, kWh	21502	2284	5458.5
		Electricity Bill amount	358940	105977	149911.2
		Total average units consumed per month, kVAh			5458.5

4. Important Parameters: CO_2 Emissions (Average, MT/Annum)

No	Consumer No.	Particulars	Value MT
1	181029037080	CO_2- Emissions- Electricity Usage	52.40
		Total	52.40

On the basis of average electricity consumption CO_2 emission is 52.40MT /annum. In addition to this LPG is being consumed for canteen for food preparation. Nearly LPG consumption annually is 300 commercial cylinders i.e. 900 kg/annum. On the basis of average LPG usage CO_2 emission is 0.9MT/annum.

5. Benchmark: In terms of Electrical Energy & CO_2 emissions:

We now present two important benchmarks in respect of Electrical Energy consumption & CO_2 emissions as under.

No	Particulars	Value	Unit
1	Electrical Energy consumed	**0.031**	kVAh/sq. ft.
3	CO_2- Emissions	**0.29**	Kg per annum /sq. ft.

6. Recommendations:

We present herewith various proposals to reduce the Electrical Energy demand and reduce the CO_2 emissions

No	Recommendation	Annual saving potential in kWh /Kg of LPG	Annual Saving Potential in MT of CO_2	Annual monetary gain, Rs.
1	Installation of 50kW Solar PV roof top on college building	84000 kWh	67.2	840000
2	Solar street lights	262.8 kWh	0.21	2628
3	Solar powered light for hoarding	-	-	-
4	Solar charging stations	-	-	-
	Total	**84262.8**	**67.41**	**842628**

Notes & assumptions:

1. 1 Unit of Electrical Energy releases 0.8 Kg of CO_2 into atmosphere
2. 1 Kg of LPG releases 3 Kg of CO_2 into atmosphere

3. Daily working hours-10
4. Annual working Days-280
5. Average Rate of Electrical Energy- Rs 10 per kWh

ABBREVIATIONS

DP	:	Double Pole
CFL	:	Compact Fluorescent Lamp
EESL	:	Energy Efficiency Services Limited
F P	:	Feeder Pillar
MSEDCL	:	Maharashtra State Electricity Distribution Company Ltd.
MEDA	:	Maharashtra Energy Development Agency
MIDC	:	Maharashtra Industrial Development Corporation
V	:	Voltage
I	:	Current
kW	:	kilo-Watt
kVA	:	Apparent Power
kVAr	:	Reactive Power
P F	:	Power Factor
kWp	:	Kilo Watt peak

CHAPTER-I
ENERGY AUDIT: INTRODUCTION

1.1 Objectives:

1. To study present level of Energy Consumption
2. To Study the present CO_2 emissions
3. To assess the various equipment/facilities from Energy efficiency aspect
4. To measure various Electrical parameters
5. To study Scope for usage of Renewable Energy
6. To study various measures to reduce the Energy Consumption

1.2 Audit Methodology:

1. Study of connected load
2. Study of various Electrical parameters
3. To prepare the Report with various ENCON measures with payback analysis

1.3 Energy Audit Instruments:

1. Portable Power Analyzer
2. Lux meter
3. Anemometer
4. Digital Temperature Indicator
5. CO_2 Meter
6. Water TDS meter

1.4 General Details of Siddhant College of Engineering, Pune

No	Head	Particulars
1	Name of Institution	Siddhant College of Engineering, Pune
2	Address	Chakan-Talegaon Road, Sudumbare, Dist.Pune – 412109
3	Year of Establishment	2005
4	Salient Features	Affiliated to Savitribai Phule Pune University
4	Courses offered	UG courses in Civil Engineering, Computer Engineering, Information technology, Electronics and Telecommunications, Mechanical Engineering PG Courses in Computer Engineering, Information technology, Electronics and telecommunications-VLSI & Embedded system, Mechanical-Design engineering
5	No of Students	1288
6	Total built up area	177066.33 Sq. ft.

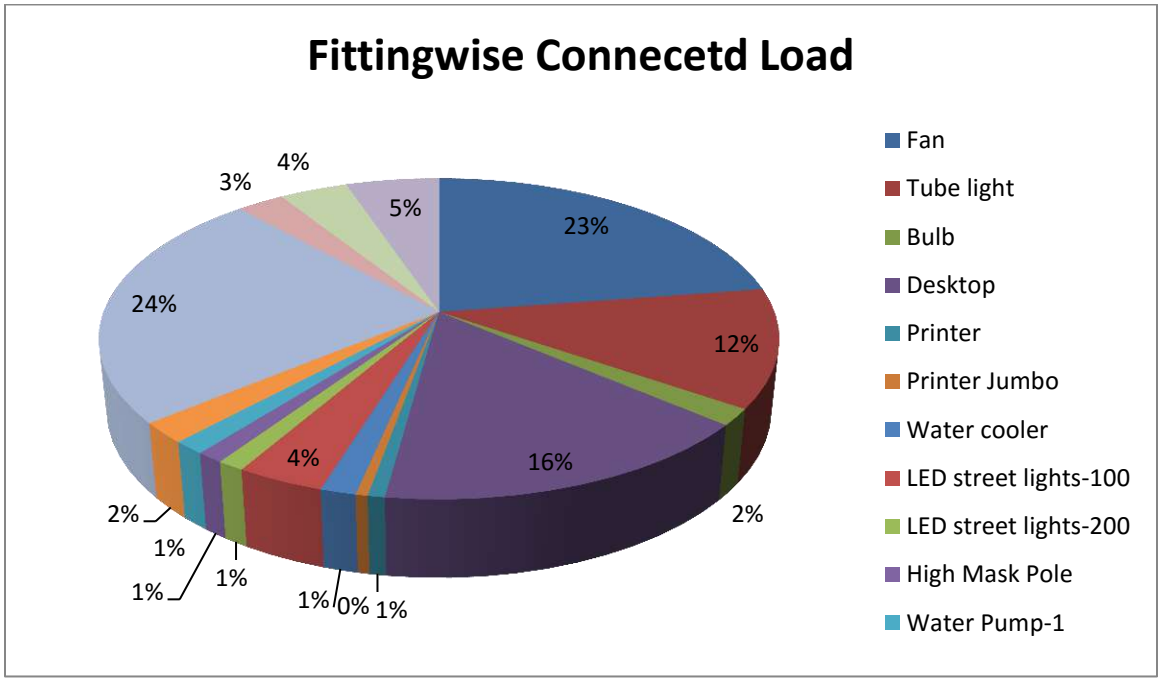
CHAPTER-II
STUDY OF CONNECTED LOAD

In this chapter, we present the details of various Electrical loads as under

2.1 Study of Fitting wise Connected Load:

Sr. No.	Types of fittings	Load/Unit	Quantity	Load in kW
1	Fan	70	465	32.6
2	Tube light	18	955	17.2
3	Bulb	60	40	2.4
4	Desktop	100	230	23.0
5	Printer	50	20	1.0
6	Printer Jumbo	352	02	0.7
7	Water cooler	352	06	2.1
8	LED street lights-100	100	52	5.2
9	LED street lights-200	200	08	1.6
10	High Mask Pole	200	08	1.6
11	Water Pump-1	372	5	1.9
12	Water Pump-2	750	4	3.0
13	Water pump-3	1300	27	35.1
14	Water pump-4	3750	1	3.8
15	Water pump-5	5500	1	5.5
16	Water pump-6	7500	1	7.5
			Total	**144.1**

We present the fitting wise connected load in a PIE Chart as under



CHAPTER-III
HISTORICAL DATA ANALYSIS: ELECTRICAL ENERGY

In this chapter, we present the analysis of last year Electricity Bills

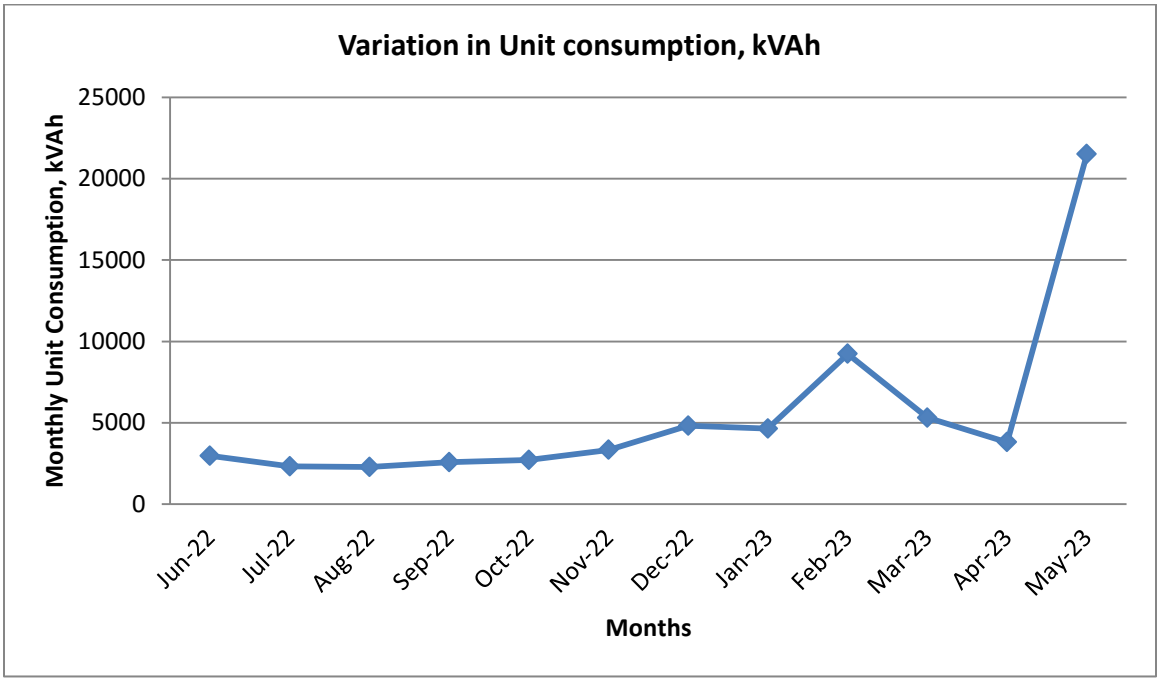
3.1 Consumer No. 181029037080

This consumer is the major contributors for billing. Monthly consumption for last few months and bill amount is as follows.

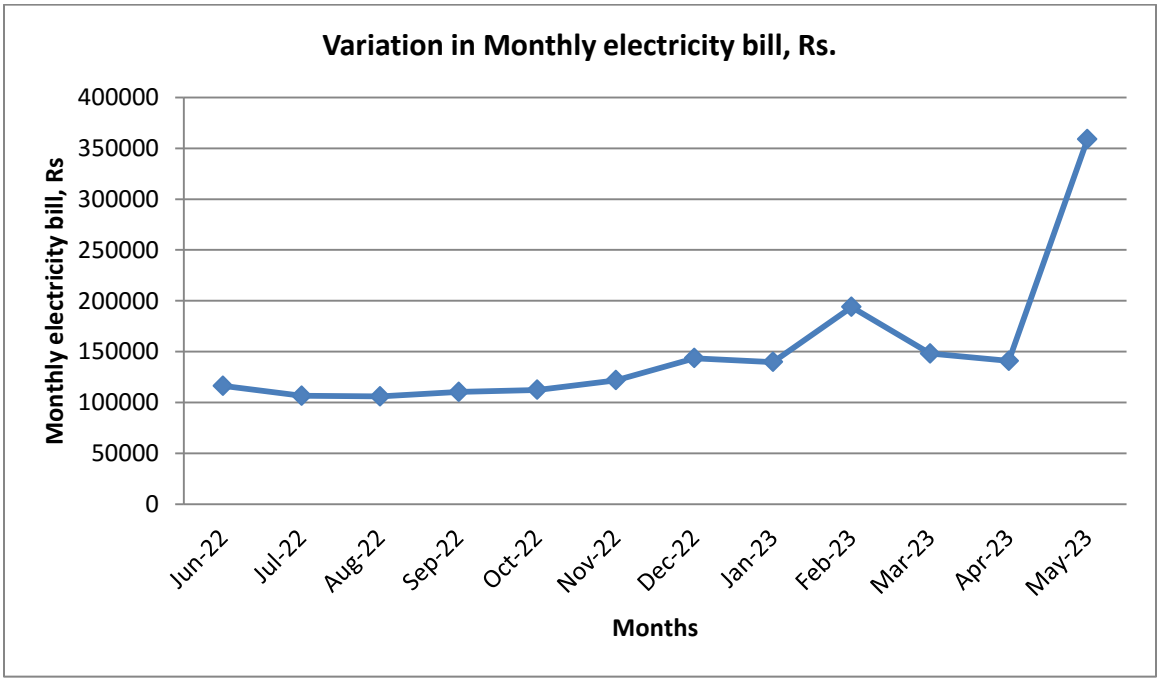
Table No. 1: Electrical Bill Analysis- 2022-23: 181029037080

Sr. No	Month	kVAh	Amount
1	May-23	21502	358940
2	April-23	3805	140921
3	March-23	5313	148093
4	Feb-23	9228	193878
5	Jan-23	4636	139895
6	Dec-22	4816	143529
7	Nov-22	3337	121916
8	Oct-22	2712	112455
9	Sep-22	2576	110397
10	Aug-22	2284	105977
11	July-22	2325	106600
12	June-22	2968	116333
13	Total	65502	1798934
14	Average	5458.5	149911.2
15	Max	21502	358940
16	Min	2284	105977

3.1.1 To study the variation of Monthly Units' Consumption:



3.1.2 To study the variation of Monthly Electricity Bill:



3.2 Summary:

Sr. No.	Consumer No.	Annual Electricity Consumption, kVAh	Annual Bill, Rs
1	181029037080	**65502**	**1798934**

3.3 Key Inference drawn:

From the above analysis, we present following important parameters:

Sr. No	Consumer No.	Parameter	Max	Min	Average
1	181029037080	Units consumed, kVAh	21502	2284	5458.5
		Electricity Bill amount	358940	105977	149911.2
		Total average units consumed per month, kVAh			5458.5

3.4 Benchmarking:

Now we compute the Electrical Energy Consumed per square feet of the College Building as under

No	Parameter	Value	Unit
1	Units consumed, kWh	**5458.5**	kVAh
2	College area	177066.33	Sq. ft.
3	**Unit consumed/sq. ft.**	**0.031**	**kVAh/sq. ft.**

CHAPTER-IV
CARBON FOOTPRINTING

A Carbon Foot print is defined as the Total Greenhouse Gas emissions, emitted due to various activities.

In this we compute the emissions of Carbon-Di-Oxide, by usage of the various forms of Energy used by the College for performing its day to day activities. The college uses electrical energy for operating various electrical gadgets.

We herewith furnish the details of electrical Energy consumption consumer number wise as under

4.1 Month wise Consumption of Electrical Energy: 181029037080

Sr. No	Month	kVAh
1	May-23	21502
2	April-23	3805
3	March-23	5313
4	Feb-23	9228
5	Jan-23	4636
6	Dec-22	4816
7	Nov-22	3337
8	Oct-22	2712
9	Sep-22	2576
10	Aug-22	2284
11	July-22	2325
12	June-22	2968
13	Total	65502
14	Average	5458.5
15	Max	21502
16	Min	2284

4.2 Basis for computation of CO_2 Emissions:

The basis of Calculation for CO_2 emissions due to Electrical Energy are as under

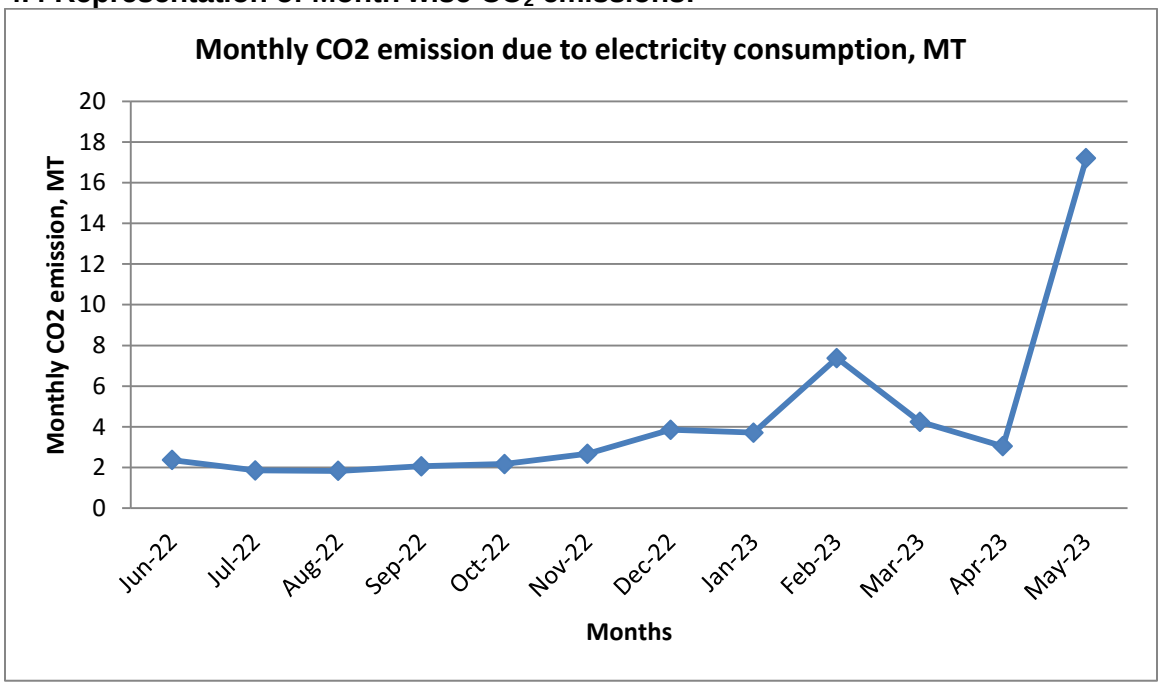
- 1 Unit (kWh) of Electrical Energy releases **0.8 Kg of CO_2** into atmosphere

Based on the above Data we compute the CO_2 emissions which are being released in to the atmosphere by the College due to its Day to Day operations.

4.3 Month wise CO2 Emissions: 181029037080

Sr. No	Month	Electrical Energy Consumed, kVAh	CO2 Emissions due to Electricity, MT
1	May-23	21502	17.20
2	April-23	3805	3.04
3	March-23	5313	4.25
4	Feb-23	9228	7.38
5	Jan-23	4636	3.71
6	Dec-22	4816	3.85
7	Nov-22	3337	2.67
8	Oct-22	2712	2.17
9	Sep-22	2576	2.06
10	Aug-22	2284	1.83
11	July-22	2325	1.86
12	June-22	2968	2.37
13	Total	65502	52.40
14	Average	5458.5	4.37
15	Max	21502	17.20
16	Min	2284	1.83

4.4 Representation of Month wise CO_2 emissions:



4.5 Benchmarking:

Now we compute the CO2 emissions per sq. ft. basis as under:

No	Parameter	Value	Unit
1	CO2 emissions	52.40	MT/annum
2	College area	177066.33	Sq. ft.
3	**CO2 emissions/sq. ft.**	**0.29**	**Kg of CO_2 per annum/sq. ft.**

CHAPTER-V
ELECTRICAL MEASUREMENTS

In this Chapter, we present the details of measurements at the distribution center and meter room of Siddhant College of Engineering, Pune

5.1 Measurement at Main Incomer feeder:

With the help of power analyzer various electrical parameters like voltage, current, KW and PF are measured. The sample extract of measured data is as follows.

Date:	Time:	U12 rms	U23 rms	U31 rms	A1 rms	A2 rms	A3 rms	F	PT (W)	PT (kW)	PFT	U12 THDr	U23 THDr	U31 THDr	A1 THDr	A2 THDr	A3 THDr
		V	V	V	A	A	A	Hz	W	kW		% r	% r	% r	% r	% r	% r
6/21/2023	12:34:00 PM	409.6	407.6	409	79	61.5	58.9	50	40059.2	40.1	0.84	1.1	1.3	0.9	15.6	7.3	6.7
6/21/2023	12:35:00 PM	411.6	409.6	411.3	80.6	61.4	59.1	49.9	40234.6	40.2	0.83	1.2	1.3	0.9	16.6	7.3	6.8
6/21/2023	12:36:00 PM	411.9	409.8	411.6	80.7	60.7	59.1	49.9	39986.8	40.0	0.83	1.2	1.3	0.9	16.7	7.3	6.8
6/21/2023	12:37:00 PM	410.4	408.5	410.2	79.7	60.6	58.9	49.9	39826.2	39.8	0.84	1.2	1.3	0.9	16	7.3	6.8
6/21/2023	12:38:00 PM	410.1	408.2	409.9	80	61.3	59.7	49.9	40422.3	40.4	0.84	1.1	1.3	0.9	16	7.1	6.7
6/21/2023	12:39:00 PM	409.7	408.3	410	91.3	61.4	60.2	49.9	40599.3	40.6	0.79	1.1	1.3	0.9	13.9	7.1	6.7
6/21/2023	12:40:00 PM	410.1	408.7	410.7	96.6	61.5	59.9	49.8	40498.0	40.5	0.76	1.1	1.3	0.9	13.1	7.1	6.7
6/21/2023	12:41:00 PM	411	409.7	411.5	96.6	61.6	60.2	49.8	40699.1	40.7	0.77	1.1	1.2	0.9	13	7.1	6.7
6/21/2023	12:42:00 PM	411.9	410.5	412.1	96.5	61.7	60.7	49.8	40989.3	41.0	0.77	1.1	1.3	0.9	12.9	7.1	6.7
6/21/2023	12:43:00 PM	411.7	410.4	412.1	96	61.7	60.7	49.8	40982.2	41.0	0.77	1.2	1.3	0.9	12.7	7.1	6.7
6/21/2023	12:44:00 PM	409.6	408	409.8	95.7	61.2	60.5	49.8	40573.5	40.6	0.77	1.2	1.3	0.9	12.6	7	6.4
6/21/2023	12:45:00 PM	408.3	406.9	408.4	95.5	60.6	60.9	49.8	40510.4	40.5	0.77	1.2	1.2	0.9	12.7	7.1	6.3
6/21/2023	12:46:00 PM	409	407.5	409	95.5	60.6	61.1	49.9	40652.2	40.7	0.77	1.1	1.2	0.9	12.8	7.1	6.3
6/21/2023	12:47:00 PM	408.3	406.8	408.4	95.1	60.4	60.9	49.8	40492.5	40.5	0.77	1.1	1.2	0.9	12.6	7.1	6.3
6/21/2023	12:48:00 PM	408.7	406.5	408.4	83.3	60.2	60.5	49.8	40291.8	40.3	0.83	1.1	1.3	0.9	14.6	7.1	6.3
6/21/2023	12:49:00 PM	410	407.7	409.5	74.1	60.2	60.3	49.9	40305.3	40.3	0.87	1.1	1.3	0.9	16.4	7.1	6.2
6/21/2023	12:50:00 PM	411.1	408.6	410.4	74.7	58.7	60.4	49.9	39712.0	39.7	0.86	1.2	1.2	0.9	16.3	7.3	6.2
6/21/2023	12:51:00 PM	411.6	409.4	410.9	76.4	58.4	60.7	49.9	39724.1	39.7	0.85	1.1	1.2	0.9	15.9	7.4	6.2
6/21/2023	12:52:00 PM	410.6	408.4	410.1	82.8	58.1	60.9	49.8	39666.0	39.7	0.82	1.1	1.2	0.9	14.6	7.4	6.3
6/21/2023	12:53:00 PM	411.7	409.5	411.2	82.5	59	60.3	49.9	39825.8	39.8	0.82	1.1	1.2	0.9	14.7	7.3	6.3
6/21/2023	12:54:00 PM	412.5	410.3	412	82.6	60.6	59.8	49.9	40275.7	40.3	0.82	1.1	1.2	0.9	14.7	7.2	6.4
6/21/2023	12:55:00 PM	413.4	411.2	412.9	83.7	61.9	59.2	50	40616.4	40.6	0.82	1.1	1.2	0.9	15.2	7	6.5
6/21/2023	12:56:00 PM	415	412.3	414.2	77	63.6	59.2	50	41360.4	41.4	0.86	1.1	1.2	0.9	17	7	6.4
6/21/2023	12:57:00 PM	417.3	414.8	416.5	76.9	63.7	59.4	50	41567.5	41.6	0.86	1.2	1.2	0.9	16.8	7	6.4

6/21/2023	12:58:00 PM	418.9	416.4	418.1	76.9	64.3	59.4	50	41957.5	42.0	0.86	1.2	1.3	0.9	16.7	6.8	6.5
6/21/2023	12:59:00 PM	418.8	416.3	418.1	77.6	64.9	59.4	50.1	42159.8	42.2	0.86	1.2	1.3	0.9	17	6.9	6.5
6/21/2023	1:00:00 PM	420.1	417.4	419.4	78.2	65.2	59.6	50.1	42438.2	42.4	0.86	1.3	1.3	0.9	17.2	6.9	6.4
6/21/2023	1:01:00 PM	421.6	418.7	420.8	77	65.5	59.6	50.1	42676.6	42.7	0.86	1.3	1.3	1	16.3	6.8	6.4
6/21/2023	1:02:00 PM	415.8	413	415.3	76.4	64.6	56.8	50.1	41386.3	41.4	0.87	1.3	1.3	1	16.3	6.9	6.2
6/21/2023	1:03:00 PM	416	413.3	415.5	76.5	65.3	56.2	50	41719.6	41.7	0.87	1.2	1.3	0.9	16.2	6.7	6.2
6/21/2023	1:04:00 PM	416.6	413.9	416	76.6	66.4	57	50	42499.6	42.5	0.88	1.2	1.3	1	15.5	6.7	6.4
6/21/2023	1:05:00 PM	415.1	412.6	414.4	76.4	66.2	57.5	50	42581.4	42.6	0.88	1.2	1.3	0.9	15.8	6.6	6.2
6/21/2023	1:06:00 PM	414.2	411.6	413.4	76.7	66.3	59.6	49.9	43218.2	43.2	0.89	1.2	1.3	1	16.1	6.6	6.1
6/21/2023	1:07:00 PM	413.1	410.6	412.3	76.2	66.1	60	49.9	43208.3	43.2	0.89	1.2	1.3	1	15.8	6.6	6
6/21/2023	1:08:00 PM	412.3	409.7	411.6	76.4	66.2	60	49.9	43149.2	43.1	0.89	1.2	1.3	1	15.7	6.6	6
6/21/2023	1:09:00 PM	413.1	410.4	412.3	75.9	66.5	60	49.9	43367.3	43.4	0.9	1.2	1.3	1	15.8	6.5	6
6/21/2023	1:10:00 PM	413.5	411.1	412.8	76.5	66.6	60.3	49.9	43506.5	43.5	0.89	1.2	1.3	1	16	6.5	6.1
6/21/2023	1:11:00 PM	414.2	411.7	413.7	77.8	66.4	60.5	49.9	43583.3	43.6	0.89	1.2	1.3	0.9	16.6	6.4	6.1
6/21/2023	1:12:00 PM	415.5	412.6	415	77.4	66.5	60.5	49.9	43769.5	43.8	0.89	1.2	1.3	1	15.9	6.5	6.1
6/21/2023	1:13:00 PM	414.5	411.7	414.1	77.1	66	60.1	49.9	43373.2	43.4	0.89	1.2	1.3	1	15.7	6.4	6.2
6/21/2023	1:14:00 PM	415.2	412.4	414.8	77.3	65.7	60.2	49.9	43325.4	43.3	0.89	1.2	1.3	1	15.8	6.4	6.2
6/21/2023	1:15:00 PM	415.9	413.2	415.6	77.6	64.6	59.7	49.9	42743.3	42.7	0.88	1.2	1.4	1	15.9	6.5	6.3
6/21/2023	1:16:00 PM	415.2	412.5	414.9	78.1	62.5	60.4	49.9	42190.8	42.2	0.87	1.2	1.3	1	16.2	6.7	6.2
6/21/2023	1:17:00 PM	416.6	414	416.2	77.7	62.5	62.2	49.9	42898.3	42.9	0.88	1.2	1.3	1	16.3	6.7	6
6/21/2023	1:18:00 PM	415.2	413.1	415.1	91.4	62.6	62.9	49.9	43113.1	43.1	0.82	1.2	1.3	1	13.8	6.7	6
6/21/2023	1:19:00 PM	415.6	413.5	415.5	84.7	51.8	52	49.9	36023.6	36.0	0.77	1.1	1.3	0.9	14.8	8.4	7.6
6/21/2023	1:20:00 PM	414.8	412.7	414.7	83.9	50.6	51	50	35306.9	35.3	0.77	1.1	1.3	1	15.6	8.6	7.7
6/21/2023	1:21:00 PM	413.8	411.7	413.6	83.2	50.5	50.9	50	35213.8	35.2	0.78	1.2	1.3	1	15	8.7	7.8
6/21/2023	1:22:00 PM	413.7	411.7	413.3	82.9	50.1	51	50	34971.7	35.0	0.77	1.2	1.4	1	15.3	8.8	7.8
6/21/2023	1:23:00 PM	412.9	411	412.4	84.1	49.7	51.5	50	34776.6	34.8	0.76	1.2	1.4	0.9	16.1	8.9	8
6/21/2023	1:24:00 PM	413	410.4	412.1	74.2	49.7	50.3	50	34010.6	34.0	0.81	1.2	1.4	1	16.7	8.8	8.3
6/21/2023	1:25:00 PM	412.6	409.9	411.8	70.3	49.6	49	50	33523.0	33.5	0.82	1.1	1.3	0.9	18.5	8.8	8.6
6/21/2023	1:26:00 PM	412.5	410	411.7	64.5	49.5	48.6	49.9	33239.5	33.2	0.85	1.2	1.4	1	20.2	8.8	8.6
6/21/2023	1:27:00 PM	414.9	412.3	414	65.4	49.7	49.6	50	33614.4	33.6	0.85	1.2	1.4	0.9	21.1	8.8	8.4
6/21/2023	1:28:00 PM	415.4	412.5	414.5	65.1	49.8	49.6	50	33671.0	33.7	0.85	1.2	1.4	1	20.5	8.8	8.4
6/21/2023	1:29:00 PM	413.8	411.2	412.9	65.3	50.1	49.5	50	33658.2	33.7	0.85	1.2	1.4	1	20	8.8	8.4
6/21/2023	1:30:00 PM	413.2	410.5	412.4	65.8	49.9	49.5	50	33568.5	33.6	0.85	1.2	1.4	1	20.3	8.8	8.3
6/21/2023	1:31:00 PM	413.2	410.4	412.2	65.7	49.5	49.7	50	33485.1	33.5	0.85	1.2	1.4	0.9	20.8	8.9	8.3

6/21/2023	1:32:00 PM	415.2	412.3	414.3	66.6	47.7	49.1	50	32759.7	32.8	0.83	1	1.2	0.9	20.7	9.4	8.6
6/21/2023	1:33:00 PM	413.6	411.2	413	71.5	45.1	46.2	49.9	30388.0	30.4	0.76	1.1	1.3	0.9	18.2	9.7	8.9
6/21/2023	1:34:00 PM	412.2	410.2	411.9	82.5	44.3	46.3	49.9	30019.0	30.0	0.7	1.1	1.3	0.9	15.9	9.8	9
6/21/2023	1:35:00 PM	108	107.5	107.9	21.9	11.1	12	49.6	7577.4	7.6	0.68	1.1	1.3	1.4	14.5	10.2	9
6/21/2023	1:36:00 PM	0	0	0	0	0	0	- - -	0.0	0.0	- - -	- - -	- - -	- - -	- - -	- - -	- - -
6/21/2023	1:37:00 PM	0	0	0	71	36	29.3	50.2	0.0	0.0	- - -	- - -	- - -	- - -	13.6	11	8.5
6/21/2023	1:38:00 PM	0	0	0	79	41.3	37.6	50.3	0.0	0.0	- - -	- - -	- - -	- - -	14.6	12.6	18
6/21/2023	1:39:00 PM	0	0	0	72.7	40	35.8	50.5	0.0	0.0	- - -	- - -	- - -	- - -	14.5	12.6	19.4
6/21/2023	1:40:00 PM	0	0	0	65.9	39.3	34.9	50.6	0.0	0.0	- - -	- - -	- - -	- - -	15.2	12.2	18.2
6/21/2023	1:41:00 PM	0	0	0	65	39.2	35.1	50.6	0.0	0.0	- - -	- - -	- - -	- - -	15.4	12.1	17.2
6/21/2023	1:42:00 PM	0	0	0	64.7	38.8	34.7	50.6	0.0	0.0	- - -	- - -	- - -	- - -	15.9	11.8	17.2
6/21/2023	1:43:00 PM	0	0	0	62.7	38.5	33.8	50.7	0.0	0.0	- - -	- - -	- - -	- - -	15.7	11.6	17.3
6/21/2023	1:44:00 PM	401.4	400.2	401	62.5	38.3	33	49.9	11376.4	11.4	0.36	1.6	1.7	1.4	17.3	8.1	10
6/21/2023	1:45:00 PM	422.5	421.3	422.2	66.5	38.6	33.2	49.8	26107.7	26.1	0.74	1.4	1.6	1.2	23.6	11.5	13.3
6/21/2023	1:46:00 PM	419.5	418.1	419.2	63.2	40.1	33.6	49.8	26537.1	26.5	0.77	1.5	1.6	1.2	20.4	11.8	15.9
6/21/2023	1:47:00 PM	418	416.5	417.6	65	39.6	33.7	49.9	26300.3	26.3	0.76	1.4	1.6	1.2	22	11	14.2
6/21/2023	1:48:00 PM	417.9	416.2	417.5	63.3	39.7	34.2	49.9	26515.0	26.5	0.77	1.3	1.6	1.2	21.1	10.8	13.5
6/21/2023	1:49:00 PM	417.8	416.2	417.5	63.7	40.2	34.5	49.9	26848.8	26.8	0.78	1.3	1.6	1.2	21.8	10.7	13.2
6/21/2023	1:50:00 PM	419.2	417.6	419.2	62.4	43.5	35.2	50	28448.7	28.4	0.81	1.4	1.6	1.2	21.6	9.8	12.8
6/21/2023	1:51:00 PM	419.4	417.7	419.4	62.6	44.8	35.5	50	29068.4	29.1	0.82	1.4	1.6	1.2	21.6	9.3	12.7
6/21/2023	1:52:00 PM	419.4	417.7	419.5	62.8	44.6	35.5	49.9	28993.0	29.0	0.81	1.4	1.6	1.2	22.1	9.3	12.8
6/21/2023	1:53:00 PM	419.4	417.6	419.4	62.9	44.8	35.3	49.9	28894.6	28.9	0.81	1.4	1.6	1.2	22.2	9.4	13.1
6/21/2023	1:54:00 PM	419.2	417.4	419	64.4	45.3	35.3	49.9	29102.3	29.1	0.8	1.4	1.6	1.2	22.6	9.5	13.3
6/21/2023	1:55:00 PM	419.3	417.4	419.2	63.9	45.5	35.3	49.9	29226.6	29.2	0.81	1.4	1.6	1.2	22.6	9.5	13.3
6/21/2023	1:56:00 PM	419	416.9	418.6	63.3	45.5	35.3	49.9	29161.8	29.2	0.81	1.4	1.6	1.2	22	9.6	13.2
6/21/2023	1:57:00 PM	419.1	417.1	418.6	63.6	45.5	35.1	49.9	29109.2	29.1	0.81	1.3	1.6	1.1	22.3	9.5	13.2
6/21/2023	1:58:00 PM	419.4	417.4	418.9	65	46.2	34.8	50	29259.4	29.3	0.8	1.4	1.6	1.2	22.2	9.2	13.4
6/21/2023	1:59:00 PM	420.4	418.3	420	63.7	46.2	35.1	50	29476.1	29.5	0.81	1.4	1.6	1.2	21.7	9.2	13.3
6/21/2023	2:00:00 PM	420.8	419	420.5	64.9	41.1	35.3	50	27621.3	27.6	0.78	1.4	1.6	1.2	22	10.6	13.5
6/21/2023	2:01:00 PM	419.6	418.1	419.4	64.3	41.2	35.3	50	27596.1	27.6	0.78	1.4	1.6	1.2	21.5	10.6	13.4
6/21/2023	2:02:00 PM	416.9	415.3	416.8	63.8	41.6	35.2	50	27546.9	27.5	0.79	1.3	1.5	1.1	21.3	10.7	13.4
6/21/2023	2:03:00 PM	415.6	413.9	415.4	63.9	41.5	35.6	50	27582.9	27.6	0.79	1.2	1.5	1.1	21.3	10.8	13.4
6/21/2023	2:04:00 PM	415.2	413.4	415.1	62.7	41.6	35.6	50	27627.8	27.6	0.8	1.3	1.5	1.1	20.6	10.8	13.4
6/21/2023	2:05:00 PM	415.3	413.5	415	62.4	42	35.7	49.9	27844.5	27.8	0.81	1.3	1.5	1.1	20.1	10.7	13.6

6/21/2023	2:06:00 PM	410.4	408.7	410.3	61.8	42.1	33.8	49.9	26873.2	26.9	0.8	1.3	1.4	1.1	19.4	10.8	14.3
6/21/2023	2:07:00 PM	408.1	406.3	408.1	62.4	41.9	33.7	49.9	26635.7	26.6	0.79	1.2	1.4	1.1	18.8	10.9	14.4
6/21/2023	2:08:00 PM	406.4	404.6	406.6	68.2	42.1	34.2	49.8	26752.4	26.8	0.76	1.2	1.4	1.1	16.9	11.4	15
6/21/2023	2:09:00 PM	404.8	403.2	405	68.8	41.7	33.9	49.8	26465.8	26.5	0.75	1.1	1.4	1.1	17.2	11.1	14.3
6/21/2023	2:10:00 PM	404.3	402.5	404.4	68.8	41.7	34.3	49.8	26567.4	26.6	0.75	1.1	1.3	1	16.9	11.3	14.3
6/21/2023	2:11:00 PM	403.1	401.3	403.3	69.4	41.6	33.8	49.8	26310.5	26.3	0.74	1.1	1.3	1	16.5	11.2	14.4
6/21/2023	2:12:00 PM	401.5	399.5	401.7	69.3	42.1	33.4	49.8	26242.7	26.2	0.75	1.1	1.3	1	16.5	10.9	14.7
6/21/2023	2:13:00 PM	401.6	399.5	401.6	69.3	42.6	33.4	49.8	26484.8	26.5	0.75	1.1	1.3	1	16.4	10.6	14.6
6/21/2023	2:14:00 PM	400.5	398.3	400.4	66.1	42.1	33	49.8	26093.3	26.1	0.77	1.1	1.4	1	17.5	10.8	14.9
6/21/2023	2:15:00 PM	399.3	397.1	398.9	61.2	42.4	32	49.8	25741.6	25.7	0.8	1.1	1.3	1	19.4	10.8	15.4
6/21/2023	2:16:00 PM	397.8	395.7	397.8	62.3	42.1	31.8	49.9	25482.8	25.5	0.79	1.1	1.3	1	20.3	10.9	15.8
6/21/2023	2:17:00 PM	396.6	394.9	396.7	71.1	42.1	31.7	49.9	25401.7	25.4	0.72	1.1	1.4	1	18.9	11	15.7
6/21/2023	2:18:00 PM	397.1	395.3	397	69.5	41.7	31.4	49.9	25198.6	25.2	0.73	1.1	1.3	1	17.7	11.1	15.2
6/21/2023	2:19:00 PM	396.2	394	395.6	68.9	41	31.6	50	24924.4	24.9	0.73	1	1.3	0.9	17.6	11.4	15
6/21/2023	2:20:00 PM	395.8	393.4	395.4	62	40.6	31.7	50	24811.1	24.8	0.78	1	1.3	1	19.9	11.4	14.6
6/21/2023	2:21:00 PM	395	392.8	394.6	61.9	40.4	31.4	50	24585.7	24.6	0.78	1.1	1.3	1	20	11.2	14.6
6/21/2023	2:22:00 PM	394.1	392	393.9	62.2	40.7	31.8	49.9	24738.4	24.7	0.78	1	1.3	1	20.2	11.1	14.3
6/21/2023	2:23:00 PM	392.8	390.5	392.5	63.3	40.6	31.9	49.9	24648.8	24.6	0.77	1.1	1.3	1	20.2	11.2	14.5
6/21/2023	2:24:00 PM	393.5	391.3	393.3	62.7	41.2	33.9	50	25591.7	25.6	0.79	1	1.3	1	19.9	10.8	13.9
6/21/2023	2:25:00 PM	394	392.1	393.8	62.6	40.9	33.2	50	25325.5	25.3	0.79	1	1.3	1	19.7	10.7	14.1
6/21/2023	2:26:00 PM	393.4	391.8	393.3	63.8	40.5	32	50	24851.9	24.9	0.77	1	1.3	1	20.1	11	14.6
6/21/2023	2:27:00 PM	394.9	393.3	394.6	63.7	40.6	32.5	50	25104.2	25.1	0.77	1.1	1.3	1	20.3	11.2	14.6
6/21/2023	2:28:00 PM	396.1	394.3	395.8	63.9	40.9	30.6	50	24595.4	24.6	0.76	1	1.4	1	20.4	11.5	15.3
6/21/2023	2:29:00 PM	397	395.1	397.1	63.9	40.9	30	50	24404.5	24.4	0.75	1	1.3	1	20.9	11.5	15.8
6/21/2023	2:30:00 PM	399.1	397.2	399.1	63.1	40.9	30.4	50	24634.4	24.6	0.76	0.9	1.1	0.9	20.2	11.6	15.7
6/21/2023	2:31:00 PM	399.2	397.3	399.2	63.7	39.7	30.2	50	24062.8	24.1	0.75	0.9	1.2	0.9	20.6	12	15.6
6/21/2023	2:32:00 PM	398.6	396.7	398.8	63.5	38.5	30.1	50	23521.9	23.5	0.74	0.9	1.2	0.9	20.5	12.3	15.5
6/21/2023	2:33:00 PM	396.5	394.8	396.6	66.8	36.9	31.4	49.9	23201.8	23.2	0.71	0.9	1.2	0.9	20.1	13	15
6/21/2023	2:34:00 PM	396.2	394.7	396.6	71	36.9	31	50	23061.2	23.1	0.68	0.9	1.2	0.8	18.2	12.9	15.3
6/21/2023	2:35:00 PM	395.1	393.6	395.3	71.7	37	29.8	50	22730.6	22.7	0.67	0.9	1.2	0.8	18.2	13	15.9
6/21/2023	2:36:00 PM	394.3	392.8	394.5	72.6	37.6	29.4	50	22764.6	22.8	0.66	0.9	1.2	0.9	19.2	12.9	16.2
6/21/2023	2:37:00 PM	393.2	392.1	393.6	72.7	37.8	29.3	49.9	22769.0	22.8	0.67	1	1.3	0.9	19.1	13.4	15.9
6/21/2023	2:38:00 PM	394.6	393.3	394.9	72.9	38.1	29.1	49.9	22871.0	22.9	0.66	1	1.3	0.9	19.3	13.4	16.2
6/21/2023	2:39:00 PM	397	395.8	397.3	71.8	39.6	29.9	49.9	23772.7	23.8	0.69	1	1.3	0.9	19.4	12.8	15.8

6/21/2023	2:40:00 PM	397.4	395.9	397.4	65.9	41.1	31.3	49.9	24725.5	24.7	0.74	1	1.2	0.9	22	12.2	15.1
6/21/2023	2:41:00 PM	396.9	395.6	396.7	67.1	41.4	31.5	49.9	24849.6	24.8	0.74	1	1.2	0.9	22.9	11.9	15.1
6/21/2023	2:42:00 PM	395.2	393.6	395.2	65.4	42.7	30.9	49.8	24896.4	24.9	0.75	1	1.3	0.9	21.5	11.7	15.2
6/21/2023	2:43:00 PM	396.3	394.8	396.4	70.3	44	31.5	49.9	25651.7	25.7	0.73	1	1.3	0.9	24	11.2	14.9
6/21/2023	2:44:00 PM	396.4	394.9	396.3	70.7	44	32.6	49.9	26036.2	26.0	0.73	1	1.2	0.9	24.4	11.1	14.3
6/21/2023	2:45:00 PM	395.9	394.3	395.8	68	43.9	32.6	49.9	25917.5	25.9	0.75	1	1.2	0.9	24.2	11.1	14.2
6/21/2023	2:46:00 PM	395.9	394.3	395.6	66.5	43.9	32.5	49.9	25905.0	25.9	0.76	1	1.3	0.9	23.6	11.1	14.3
6/21/2023	2:47:00 PM	397.1	395.2	396.6	63.1	43.9	32.4	50	25896.0	25.9	0.78	1	1.3	0.9	21.1	11	14.1
6/21/2023	2:48:00 PM	397.3	395.4	396.8	65.7	44	32.2	49.9	25869.0	25.9	0.76	1	1.3	0.9	23.3	10.9	13.8
6/21/2023	2:49:00 PM	397	395.2	396.4	64	43.9	33.1	50	26212.5	26.2	0.78	1	1.3	0.9	24	10.9	13.5
6/21/2023	2:50:00 PM	397.4	395.6	396.7	62.8	43.9	33.3	50	26307.8	26.3	0.79	1	1.3	0.9	23.9	10.8	13.7
6/21/2023	2:51:00 PM	397.3	395.2	396.8	60.8	44.6	34.4	50	26846.9	26.8	0.82	1	1.3	1	23.1	10.8	13.8
6/21/2023	2:52:00 PM	397.7	395.4	396.9	60.9	44.6	34.6	50	26940.0	26.9	0.82	1	1.3	0.9	22.4	10.7	13.8
6/21/2023	2:53:00 PM	399.2	397.2	398.4	60.6	45.1	33.8	50	26940.3	26.9	0.82	1	1.3	0.9	22.5	10.5	14.1
6/21/2023	2:54:00 PM	399.9	398	399.3	63.1	45.4	33.7	50	27040.5	27.0	0.8	1.1	1.3	0.9	24.6	10.4	14.3
6/21/2023	2:55:00 PM	400.4	398.2	399.9	61.6	45.6	33.8	50	27174.1	27.2	0.81	1.1	1.2	0.9	25.5	10.7	14.2
6/21/2023	2:56:00 PM	400	398.1	399.6	61.4	45.6	34	50	27233.8	27.2	0.81	1.1	1.3	0.9	25.7	10.8	14.3
6/21/2023	2:57:00 PM	400.6	398.7	400.1	62.4	45.7	34	50	27264.8	27.3	0.81	1.1	1.3	0.9	26.1	10.8	14.4
6/21/2023	2:58:00 PM	400.5	398.6	400	61.5	45.7	33.9	50	27195.9	27.2	0.81	1.1	1.3	0.9	25.5	10.8	14.3
6/21/2023	2:59:00 PM	399.1	397.1	398.7	61.7	45.5	33.8	50	27024.5	27.0	0.81	1.1	1.3	0.9	25.4	10.7	14.2
6/21/2023	3:00:00 PM	401.1	399.2	400.9	60.2	45.9	33.8	50.1	27334.9	27.3	0.82	1.1	1.3	0.9	23.2	10.8	14.2
6/21/2023	3:01:00 PM	401.5	399.4	401.1	58.9	45.5	32.3	50.1	26690.4	26.7	0.82	1.1	1.3	0.9	22.8	10.9	14.8
6/21/2023	3:02:00 PM	401.7	399.7	401.4	58.6	45.1	31.1	50	26071.5	26.1	0.81	1.1	1.3	0.9	23	10.9	15.6
6/21/2023	3:03:00 PM	400.6	398.5	400.4	58.2	44.5	30.8	50	25704.1	25.7	0.81	1.1	1.3	0.9	23	11	15.6
6/21/2023	3:04:00 PM	401.2	399	400.8	57.5	43.8	30.8	50	25476.0	25.5	0.81	1.1	1.3	0.9	23.2	11.3	15.8
6/21/2023	3:05:00 PM	400.1	398	399.4	53	40.8	27.1	50	23067.8	23.1	0.8	1.1	1.3	1	25.1	12.5	18.3
6/21/2023	3:06:00 PM	399.3	397.4	398.8	52.7	39.5	26.6	50	22393.4	22.4	0.79	1.1	1.3	1	25.2	13	18.4
6/21/2023	3:07:00 PM	401.5	399.5	401.1	53.5	35.8	25.7	50	20808.2	20.8	0.75	1.1	1.3	0.9	25.8	14.6	19.2
6/21/2023	3:08:00 PM	401.5	399.5	400.8	51.9	35.2	24.4	50	20113.8	20.1	0.75	1.2	1.3	1	26.2	15.1	20.6
6/21/2023	3:09:00 PM	399	397.1	398.4	52.3	35	24	50	19826.0	19.8	0.74	1.1	1.3	1	25.2	15.3	21
6/21/2023	3:10:00 PM	398.9	397.1	398.4	52.8	35.5	23.3	49.9	19684.2	19.7	0.73	1.1	1.3	0.9	25.9	15.1	21.9
6/21/2023	3:11:00 PM	398.1	396.3	397.9	58.3	35.5	22.2	49.9	19234.6	19.2	0.67	1.1	1.3	0.9	23.1	15	23
6/21/2023	3:12:00 PM	398.1	396.4	397.9	59.3	35.3	21.9	50	19097.2	19.1	0.66	1.1	1.3	0.9	21.9	14.9	23.5
6/21/2023	3:13:00 PM	397.7	396.3	398	67.8	35	20.9	50	18617.8	18.6	0.59	1.1	1.3	0.9	19.1	15.1	24.4

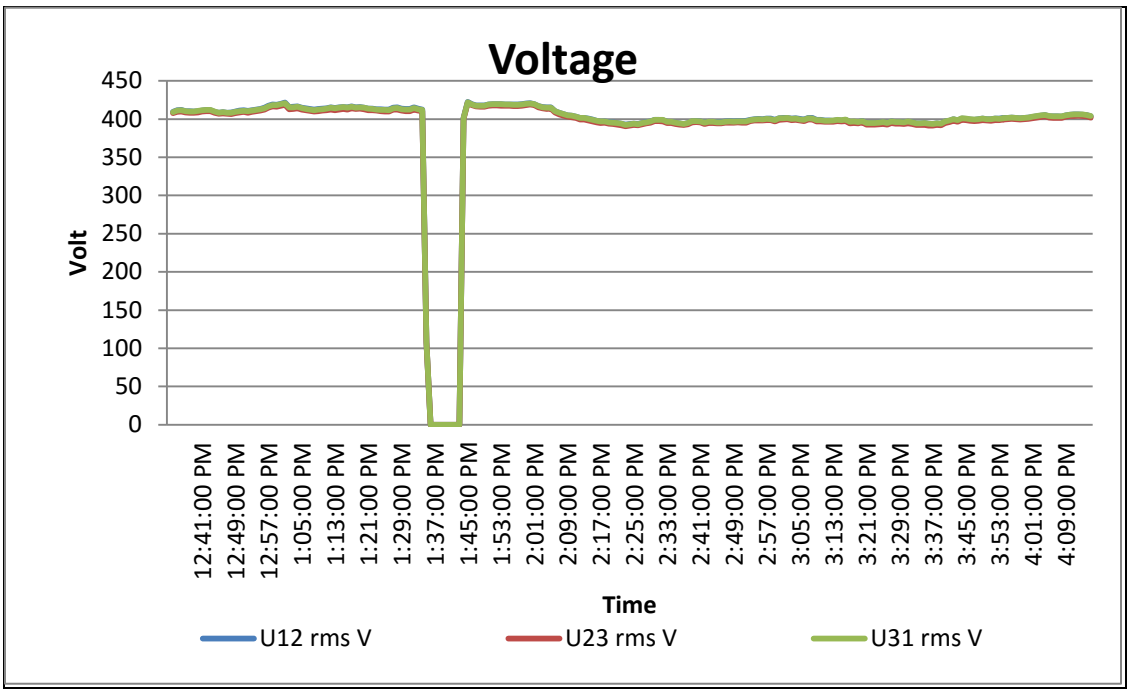
6/21/2023	3:14:00 PM	398.4	397.2	398.9	71.4	35	21	50.1	18669.0	18.7	0.57	1.1	1.3	0.9	18.8	15	24.6
6/21/2023	3:15:00 PM	398.2	396.8	398.6	70.5	35	21.1	50.1	18713.7	18.7	0.58	1	1.3	0.9	18.3	14.8	24.2
6/21/2023	3:16:00 PM	398.9	397.5	399.3	69.6	36.3	21.2	50.1	19169.4	19.2	0.59	1.1	1.3	0.9	18.5	14.1	23.7
6/21/2023	3:17:00 PM	395.9	394.5	396.4	69.7	36	21	50.1	18948.8	18.9	0.59	1	1.3	0.9	18.7	14.2	23.6
6/21/2023	3:18:00 PM	396.3	394.9	396.7	69.1	35.8	21.1	50.1	18954.9	19.0	0.59	1.1	1.3	0.9	19.3	14.2	23.8
6/21/2023	3:19:00 PM	396	394.2	396.2	61.3	34.6	20.6	50.1	18357.3	18.4	0.63	1	1.2	0.9	22.8	14.8	24.5
6/21/2023	3:20:00 PM	397.5	395.5	397.5	53.3	34.7	19.8	50.1	18149.3	18.1	0.69	1	1.2	0.9	25.9	15.3	25.2
6/21/2023	3:21:00 PM	394.9	392.9	394.8	58.5	34.7	19.6	50.1	18004.7	18.0	0.64	1	1.2	0.9	24.6	15.5	25.5
6/21/2023	3:22:00 PM	395	392.8	395	54.3	34.6	20.9	50.1	18363.7	18.4	0.69	1	1.1	0.9	25.2	15.4	23.8
6/21/2023	3:23:00 PM	395	392.6	395	54.4	34.5	21.3	50.1	18465.3	18.5	0.69	1	1.1	0.9	25.2	15.3	23.2
6/21/2023	3:24:00 PM	395.4	393.1	395.4	54.5	35.1	20.7	50.1	18517.8	18.5	0.69	1	1.2	0.9	25.3	15.1	23.6
6/21/2023	3:25:00 PM	395.7	393.7	396.1	53.3	34.6	21.1	50.1	18467.9	18.5	0.7	1	1.2	0.9	24.9	15.3	22.8
6/21/2023	3:26:00 PM	394.8	392.7	394.9	52.4	35	20.5	50.1	18379.9	18.4	0.7	1	1.1	0.8	24.8	15.2	23.2
6/21/2023	3:27:00 PM	397.1	394.8	397.1	51.5	34.2	18.5	50.1	17546.3	17.5	0.68	1	1.2	0.8	24.8	15.4	25.8
6/21/2023	3:28:00 PM	396	393.9	396.2	51.9	34.6	18.4	50.1	17637.2	17.6	0.68	1	1.2	0.9	24.9	15.4	26.1
6/21/2023	3:29:00 PM	395.9	393.8	396.2	52.3	34.6	18.4	50.1	17603.9	17.6	0.68	1	1.2	0.9	25	15.9	26.3
6/21/2023	3:30:00 PM	395.5	393.5	395.8	52.1	34.6	18.3	50.1	17589.5	17.6	0.68	1.1	1.2	0.9	24.6	16.2	26.3
6/21/2023	3:31:00 PM	396.5	394.4	396.8	52.2	35.3	18.5	50.1	17865.3	17.9	0.69	1.1	1.2	0.9	24.6	16.1	25.8
6/21/2023	3:32:00 PM	395.5	393.4	395.7	52.8	34.9	18.5	50.1	17712.5	17.7	0.68	1.1	1.2	0.9	25.1	15.9	25.7
6/21/2023	3:33:00 PM	394.4	392.2	394.4	52.8	34.7	18.2	50.1	17520.9	17.5	0.68	1	1.2	0.8	24.8	16.1	25.9
6/21/2023	3:34:00 PM	394.3	392.1	394.4	52.2	34.6	18.1	50	17451.1	17.5	0.68	1.1	1.2	0.9	24.9	16	26
6/21/2023	3:35:00 PM	394.6	392.4	394.9	52.3	34.4	18.4	50	17464.4	17.5	0.68	1	1.2	0.8	24.9	15.6	25.6
6/21/2023	3:36:00 PM	393.9	391.6	393.9	52.4	34.4	18.7	50	17518.4	17.5	0.68	1.1	1.2	0.9	25.1	15.6	25.9
6/21/2023	3:37:00 PM	393.4	391.4	393.6	52.6	34.5	18.9	50	17572.9	17.6	0.68	1.1	1.3	0.9	25.6	15.8	26.9
6/21/2023	3:38:00 PM	394.2	392.2	394.4	51.9	34.4	20.5	50	17548.9	17.5	0.68	1.1	1.3	0.9	26.4	15.7	24.9
6/21/2023	3:39:00 PM	393.7	391.7	393.9	52.3	34.6	22	50	17857.0	17.9	0.68	1.1	1.3	0.9	26.8	15.8	24
6/21/2023	3:40:00 PM	396.8	394.9	396.8	53.2	35.2	22.1	50	18225.2	18.2	0.68	1.1	1.3	0.9	27.2	15.5	24
6/21/2023	3:41:00 PM	397.9	396.1	398.2	58.8	35.3	22.2	50	18341.0	18.3	0.64	1.1	1.3	0.9	23.1	15.3	23.7
6/21/2023	3:42:00 PM	399.8	397.9	400	59	35.4	22.1	50	18404.8	18.4	0.64	1.1	1.3	0.9	23.2	15.3	23.7
6/21/2023	3:43:00 PM	398.3	396.4	398.7	59.4	35.3	22.1	50	18336.7	18.3	0.63	1.1	1.3	0.9	23.6	15.3	24.2
6/21/2023	3:44:00 PM	400.7	399	401.2	58.9	35.5	22.3	50	18527.7	18.5	0.64	1.1	1.3	0.9	23.1	15.3	24
6/21/2023	3:45:00 PM	400.2	398.6	400.7	58.7	35.4	21.9	50	18381.9	18.4	0.64	1.1	1.3	0.9	23	15.3	24.5
6/21/2023	3:46:00 PM	399.4	397.9	399.9	58	35.4	21.8	50	18309.5	18.3	0.64	1.1	1.3	0.9	23.4	15.5	24.8
6/21/2023	3:47:00 PM	399.1	397.4	399.6	57.6	35.3	22	50	18301.7	18.3	0.65	1.1	1.3	0.9	23.6	15.5	24.3

6/21/2023	3:48:00 PM	399.7	397.9	400	52	35.3	22.8	50	18491.2	18.5	0.69	1.1	1.3	0.9	26.4	15.3	23.2
6/21/2023	3:49:00 PM	400.6	398.6	400.7	51.9	34	22.8	50	17921.8	17.9	0.68	1.1	1.2	0.9	25.8	15.9	23
6/21/2023	3:50:00 PM	399.9	398	400	51	32.9	22.8	50	17385.3	17.4	0.67	1.1	1.3	0.9	25.6	16.4	23
6/21/2023	3:51:00 PM	399.8	397.8	400	51.7	33	22.8	50	17390.3	17.4	0.66	1.1	1.2	0.9	26.2	16.5	22.9
6/21/2023	3:52:00 PM	400.7	398.7	400.7	52.7	33.2	23.2	50	17620.3	17.6	0.66	1.1	1.2	0.9	26.9	16.6	22.7
6/21/2023	3:53:00 PM	400.5	398.7	400.4	55.9	31.5	22.9	50	17056.7	17.1	0.63	1.1	1.2	0.9	29	17.4	23.4
6/21/2023	3:54:00 PM	401.3	399.4	401.1	52.2	29.6	22.4	50	16136.2	16.1	0.63	1.1	1.2	0.9	26.1	18.3	23.6
6/21/2023	3:55:00 PM	401.7	399.7	401.5	52.2	28.9	22	50	15721.6	15.7	0.62	1.1	1.2	0.9	25.9	18.7	23.9
6/21/2023	3:56:00 PM	402	400.3	401.9	54.4	28.8	22.5	50	15864.0	15.9	0.6	1.1	1.3	0.9	27.2	18.5	23.7
6/21/2023	3:57:00 PM	401.6	399.9	401.6	54.5	28.9	21.9	50	15650.5	15.7	0.6	1.1	1.2	0.9	27.8	18.7	24.3
6/21/2023	3:58:00 PM	401.2	399.4	401.1	52.4	28.6	22.2	50	15654.5	15.7	0.61	1.1	1.2	0.9	25.8	18.4	24.1
6/21/2023	3:59:00 PM	401.6	399.8	401.7	52.2	28.5	22	50	15552.2	15.6	0.61	1	1.1	0.8	26	18.2	24.2
6/21/2023	4:00:00 PM	401.8	400.2	402	54.4	29.7	21.9	50.1	15937.1	15.9	0.6	1.1	1.2	0.9	26	17.7	24.3
6/21/2023	4:01:00 PM	402.9	401.2	403	57.1	31.1	21.9	50.1	16484.6	16.5	0.6	1.1	1.2	0.9	25.9	17.1	24
6/21/2023	4:02:00 PM	403.7	402.1	404	56.1	30.6	21.9	50.1	16315.4	16.3	0.6	1.1	1.2	0.9	25.5	17.4	24
6/21/2023	4:03:00 PM	404.5	402.7	404.8	57.1	30.6	21.8	50.1	16358.6	16.4	0.59	1.1	1.2	0.9	26.4	17.2	23.7
6/21/2023	4:04:00 PM	405.1	403.4	405.3	55.7	30.6	21.7	50.1	16332.7	16.3	0.6	1.1	1.1	0.8	27	17.2	23.4
6/21/2023	4:05:00 PM	403.7	402	404	54.8	30.7	21.5	50.1	16228.4	16.2	0.61	1.1	1.1	0.8	26.2	17.3	23.6
6/21/2023	4:06:00 PM	403.4	401.7	403.8	57.1	31.2	21.4	50.1	16388.5	16.4	0.59	1.1	1.2	0.9	26.7	17	24.1
6/21/2023	4:07:00 PM	403.4	401.5	403.7	56	30.6	21.4	50.1	16121.3	16.1	0.59	1.1	1.1	0.9	25.9	17.3	23.7
6/21/2023	4:08:00 PM	403.3	401.6	403.6	56.1	30.9	21.3	50.1	16174.4	16.2	0.59	1.1	1.2	0.9	26.1	17	23.5
6/21/2023	4:09:00 PM	404.7	403	405	54.4	31.5	20.8	50	16202.6	16.2	0.61	1.1	1.2	0.9	25.3	16.4	23.2
6/21/2023	4:10:00 PM	405.7	403.9	405.9	54.1	31.4	20.8	50	16220.6	16.2	0.61	1	1.2	0.9	25.1	16.2	22.9
6/21/2023	4:11:00 PM	406	404.1	406.3	55.4	30.2	20.9	50	15707.1	15.7	0.58	1.1	1.2	0.9	25.9	16.6	23
6/21/2023	4:12:00 PM	406.1	404.4	406.3	54.7	30	20.9	50	15591.4	15.6	0.58	1.1	1.2	0.9	25.8	16.6	23.1
6/21/2023	4:13:00 PM	405.8	404.1	406.1	55.3	29.9	20.8	50	15532.0	15.5	0.58	1.1	1.2	0.9	26.2	16.7	23
6/21/2023	4:14:00 PM	405.2	403.4	405.3	54.8	29.8	20.8	49.9	15460.1	15.5	0.58	1.1	1.1	0.8	25.9	16.7	22.9
6/21/2023	4:15:00 PM	403.7	401.9	404	55.3	28.7	20.2	50	14873.8	14.9	0.56	1	1.1	0.8	26.2	17.1	23.4

5.2 Variation in Electrical Parameters

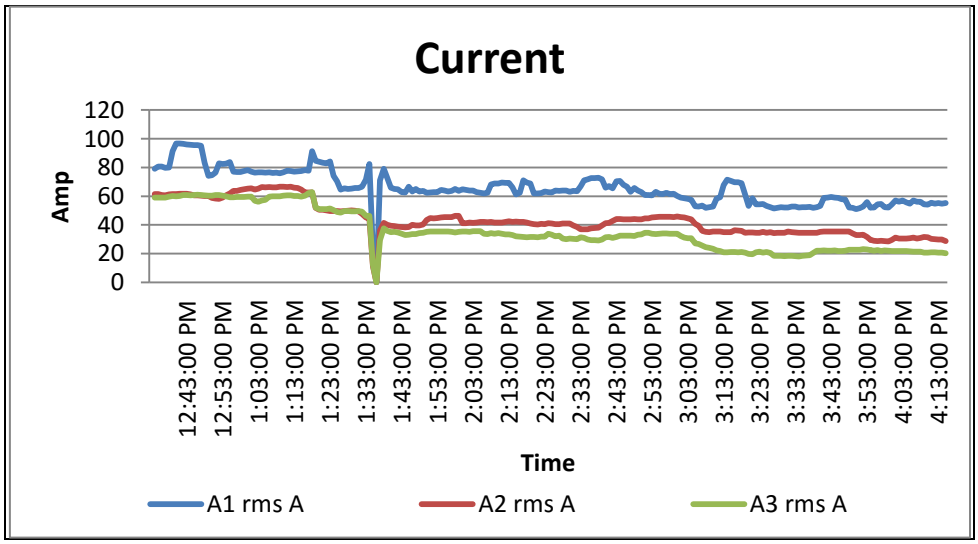
Now we present the variation in various Electrical parameters as under.

5.2.1 Voltage



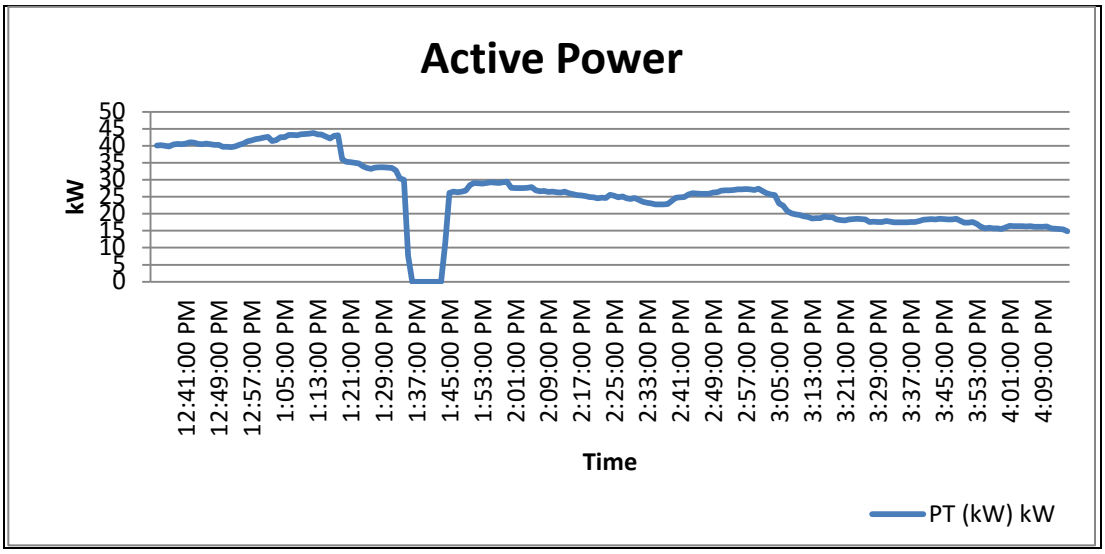
Average voltage is around 388 V of transformer.

5.2.2 Current



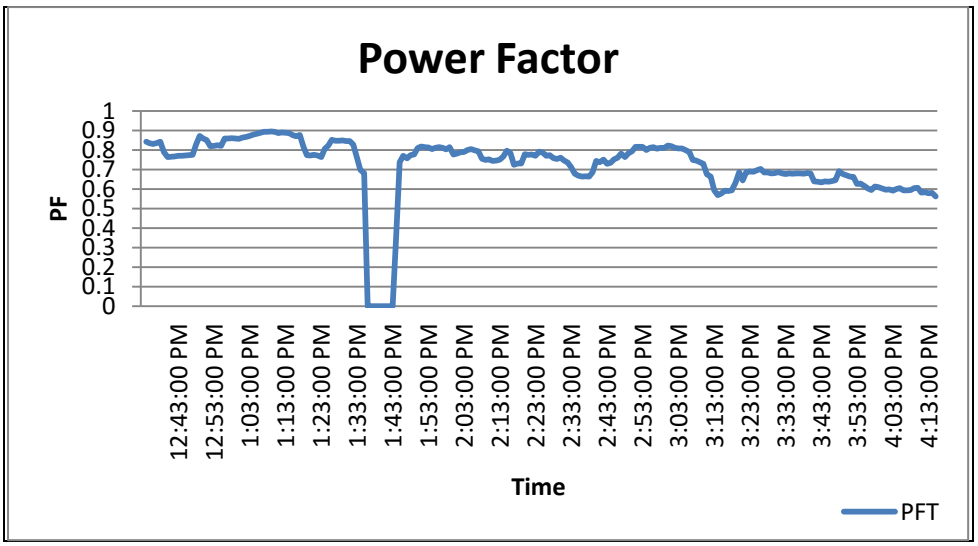
Current variation is load variation. Average current is around 48.3A.

5.2.3 Total Active power (kW)



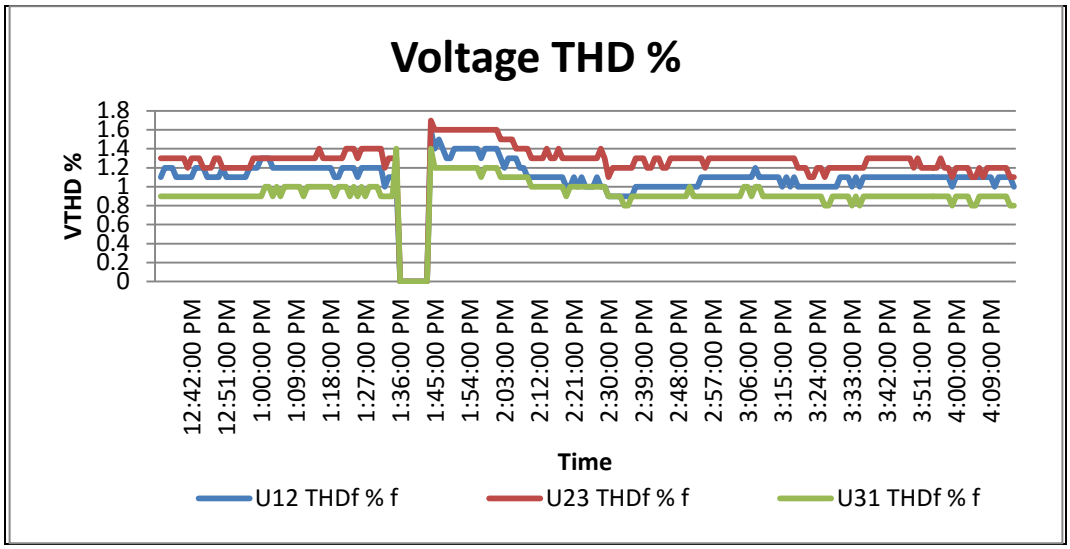
Variation in load demand can be observed in the graph. Average power consumption of the facility is around 26 kW.

5.2.4 Power factor



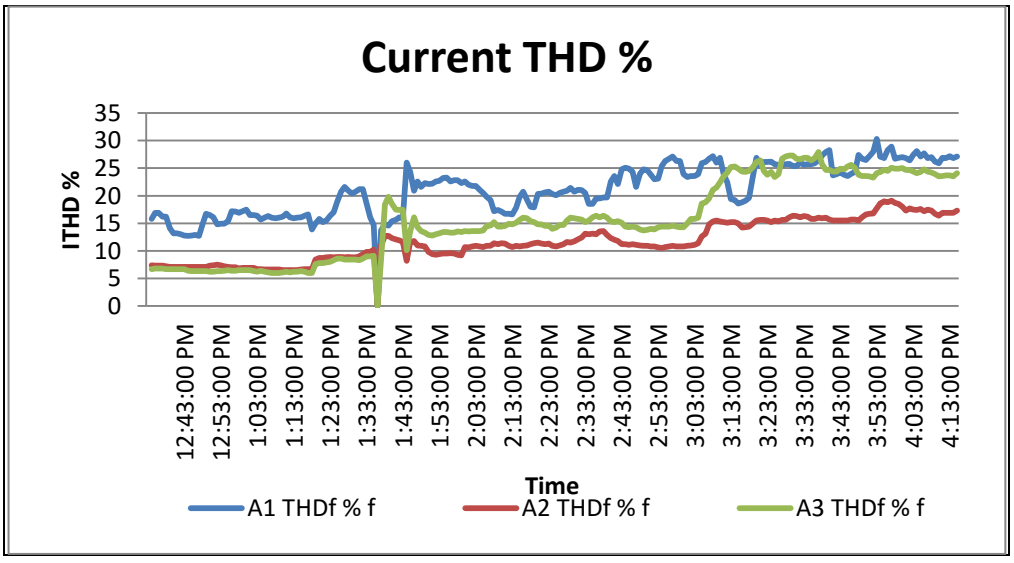
Average power factor is 0.745.

5.2.5 Voltage THD%



Average voltage harmonic distortion is 1.1 %.

5.2.6 Current THD%



Average current harmonic distortion is 16.2% whereas peak is 25%.

CHAPTER-VI
SCOPE OF RENEWABLE ENERGY AND EFFICIENT FACILITY AT COLLEGE CAMPUS

6.1 Installation of 221 kWp Solar PV Power Plant:

Solar roof top power plant having capacity 221 kWp is installed on Siddhant Pharmacy College building and Siddhant School building, at college campus which meets the requirement of electricity demand of these buildings. The Solar roof top plant is successfully installed and it is in operation to meet the requirement of electricity of institute campus building. The existing solar roof top installed technical specifications and details are given below.

Technical Specifications:

Siddhant College of Engineering, Pune has installed solar roof top power plant. The brief specifications and details of the plant are mentioned below.

- **System Capacity:** 221 kW
- **PV Module:** Navitas Solar, 325 Wp Polycrystalline – 680 nos.
- **Output:** 5.5 kWh/Sq.m/day (All output is under STC, 25°C)
- **Inverter**: Growatt- 30kWp-6 Inverters

Photo-2: 221 kW solar roof top on Siddhant School building roof.

6.2. DG sets

Two DG sets, of capacity 125kVA and 100KVA are installed at Siddhant College of Engineering, campus Pune as backup for provision of electricity.

Photo-4: DG set up at Siddhant College of Engineering, campus Pune

6.3 Solar powered light for hoarding

Lighting solar systems are the fixed installations designed for domestic as well as small scale commercial application. The component of the solar lighting system includes solar PV module (solar cells), charge controller, solar battery and lighting system (lamps & fans). Modules are installed in the open on roof/terrace - exposed to sunlight and the charge controller and battery are kept inside a protected place in the house.

Figure-1: Solar powered light for Hoarding

This system comes with multiple benefits such as:

- **Economical:** Since the sun provides energy free of charge, 30% power savings on the electricity bill can be availed with longer back up lighting system at zero running cost.
- **Non-Polluting:** Powered by the sun's renewable energy, the system is energy neutral and an absolutely clean source of illumination. 1kWp solar installation reduces 1⁄2 ton of CO_2 (carbon dioxide) per annum.
- **No Maintenance:** The system has few moveable parts – reducing the risk of breakage. Once installed, it lasts for long time and requires little attention.

This system can be used to power the huge hoardings in the college campus.

Solar powered hoarding lighting system proposed will provide a better, faster, cheaper (and cleaner) alternative with solar. Since this product competes with diesel or conventional fuels, we needed to ensure we beat the cost of a diesel solution. In order to achieve that with solar, we consider the following system:

1. Highly Efficient Solar Panel

2. Charge Controllers with MPPT Technology – increases solar electricity production by up to 30% compared to conventional charge controllers

3. LED Projection Light – consumes 10-times less electricity compared to conventional bulbs, and has a 50,000 hour warranty.

Features:

- Auto on off
- 4 Days Battery Back Up
- Robust housing
- Weather proof

With this entire put together, we ended up with systems that provide 6 hours of lighting each night with 4 -lamp system to light up boards up to 15′x30′, and a 8-lamp system to light larger boards up to 20′x40′.More importantly, with these options, payback of the system will come around 2.5 years. This system provides a way to reduce the lightings costs, get rid of all the operational hassles of owning a diesel generator, plus brand benefits from being "green" with the use of renewable energy like solar powered light hoarding board.

6.4 Solar charging stations

Solar cell phone chargers use solar panels to charge cell phone batteries. They are an alternative to conventional electrical cell phone chargers and in some cases can be plugged into an electrical outlet. Solar mobile charger is a device which can charge mobile phones using solar radiation. Its major component is a compact solar panel. This solar panel traps solar energy and produces an output voltage. But, since the light radiations falling on the solar panel can vary, the output voltage becomes unstable. For charging a mobile phone, stable voltage is required. So, to

make the output voltage stable and regulated, voltage regulator circuit along with the solar panel is used.

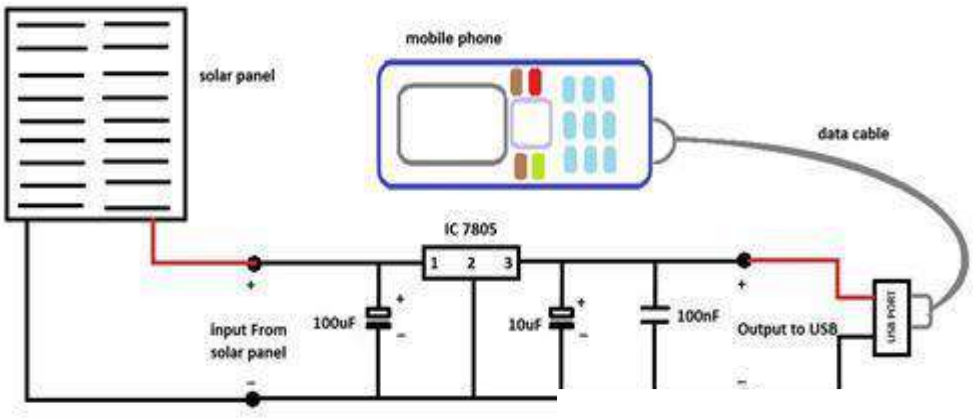


Figure-4: Solar charging Stations

Most of the mobile phones have computer connectivity via USB cable. USB port establishes 4 connection terminals. The connection terminals at the two extreme ends are the supply terminals. In a female USB connector (port via which we plug in USB devices to computer), these terminals carry 5V DC. When a mobile phone is connected to the USB port of a computer, it utilizes this 5V supply to recharge battery. This feature is used in a solar mobile charger. It converts and regulates solar energy to 5V DC and the output will be available through the female USB connector. To this connector, we can easily connect a mobile phone via data cable.

6.5 Installation of 50 kWp Solar PV roof Top on Siddhant College of Engineering, building:

During the Audit, it was revealed that the College has space on the Terrace. It is proposed to install a Solar Photovoltaic roof top with net meter of capacity **50 kWp.** The system will cater the Day load Demand of the College.

We furnish herewith the saving potential as under

No	Particulars	Value	Unit
1	Installed Capacity of Solar PV Pack	50	kWp
2	Daily working period	6	Hrs./Day
3	Daily units generated	300	kWh/Day
4	Annual working days	280	Day/annum
5	Annual saving in Grid Electrical Energy	84000	kWh/annum
6	Annual CO_2 saving potential	67.2	MT/Annum

7	Present Energy Charges	10	Rs/kWh
8	Annual monetary Gain	840000	Rs/Annum
9	Investment required	22,50000	Rs lump sum
10	Payback period	2.67	Years

Chapter VII
SUGGESTIONS AND RECOMMENDATIONS

Following Energy Conservation Opportunities and actions on the basis of energy audit are suggested to implement in the campus on the basis of funds availability and institute preferences.

Energy Audit: Energy Conservation opportunities:

- Energy efficient tubes and fans can be replaced. Already energy efficient lightings are installed at prominent places like admin office, corridor etc.
- Installation of 50 kW solar roof top system as space available on the roof of the college building. As sanctioned load is 300kW, the additional solar roof top of 50 kW capacity with net meter can be installed in the college campus to meet the requirement of electricity.
- Installation of Solar powered light for hoarding.
- Installation of 05 Nos. solar mobile phone charging stations in the college campus.
- Water management system must be in place. Overhead tanks can be with float control and Time of the day (TOD) can be implemented for water pumping for filling the overhead water tanks.

C. A. Y. M. E. Trust's
Siddhant College of Engineering.
(Approved by AICTE, Recognized by Govt. of Maharashtra and Affiliated to S.P. Pune University & MSBTE)
At. Post - Sudumbare, Tal. - Maval, Dist. - Pune, PIN - 412 109. ☎ 02114-661904.

Shri. Rajendra Singh Yadav.
President.

Environmental Awareness beyond the Campus

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