Bharatiya Vidya Bhavan

Bhavan's Vivekananda College

of Science, Humanities & Commerce

Autonomous College - Affiliated to Osmania University

Accredited with 'A' grade by NAAC

Sainikpuri, Secunderabad - 500094

NAAC RE-ACCREDITATION - 2ND CYCLE

Criterion VII

Institutional Values and Best Practices

7.1.6

Environmental consciousness and sustainability

Green Audit Report

Submitted to

National Assessment and Accreditation Council

GREEN AUDIT

OF

BHAVAN'S VIVEKANANDA COLLEGE OF SCIENCE, HUMANITIES AND COMMERCE

SAINIKPURI, SECUNDERABAD

APRIL 2021

PROJECT PROPONENT	ENVIRONMENTAL CONSULTANT
Bhavan's Vivekananda College of Science, Humanities and Commerce, **Sainik Puri** **Secunderabad** **Telangana - 500094**	**B.S. ENVI-TECH PVT. LTD.,** **Secunderabad, Telangana.** **NABET Accreditation:** **NABET/EIA/1922/RA 0174**

B.S. ENVI - TECH PVT. LTD.
CONSULTANTS - ENVIRONMENT & ENERGY

AUDIT CERTIFICATE

This to Certify that B.S.ENVITECH PVT LTD (BSET), has conducted the GREEN AUDIT, ENVIRONMENT AUDIT AND ENERGY AUDIT OF BHAVAN'S VIVEKANANDA COLLEGE OF SCIENCE, HUMANITIES AND COMMERCE, SAINIKPURI, SECUNDERABAD during April 2021.

The Audit of the premises, review of data and implementation of measures by the Management was done by BSET.

The implementation of GREEN MEASURES by the Management, Faculty and Students towards Environment Sustainability is commendable and Satisfactory.

BS ENVI-TECH PVT. LTD. SEC'BAD.

DATE: 19th April, 2021

Y.B.S.MOORTHY,

PLACE: SECUNDERABAD

QCI/NABET APPROVED EIA COORDINATOR,
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Executive Summary

The Management of Bhavan's Vivekananda College (BVC), Sainikpuri, Secunderabad assigned the task for conducting the Green Audit of Bhavan's Vivekananda College campus to B.S.Envi-tech Pvt Ltd (BSET) – a QCI/NABET Accredited Consultant Organization.

BSET team initiated the audit with a pre-audit meeting with the Principal and Staff. This provided an opportunity to reinforce the scope and objectives of the audit and discussions were held on the practicalities associated with the audit without disturbing the functioning of the College.

A detailed walkthrough audit of various facilities at the college like water system, electricity systems, wastewater management, solid waste management, housekeeping, parking area, stormwater system, rainwater harvesting, landscaping, DG sets, Roof top solar systems was carried out with the help of Senior Staff members nominated by the Principal for this Audit. Subsequently a detailed checklist was shared to the BVC team for review.

The audit team identified the Target areas and prepared an action plan for collection of historic data and primary sampling of environmental parameters. The analysis of Environmental parameters pertaining to Ambient Air Quality, Water, Noise levels were analyzed at BSET's NABL accredited Analytical Laboratory. The Remote sensing imagery data was obtained from NRSC, and the Land use was analyzed.

The Management of the College must be appreciated for taking pro-active steps like implementation of Roof top solar system, Rainwater harvesting, Greenery development , good housekeeping, waste minimization, Green Chemistry, Conducting awareness programs, establishment of ***greEnergy Club***. This was possible by the active involvement of the Management, Faculty and Students.

This audit report has recommended certain areas for improvement which will enhance the College further in the Conservation of Energy and Environment and thereby reduction in Carbon footprint.

1.0 Acknowledgement

B. S. Envi-Tech (P) Limited is accredited as Category "A" Consultant by National Accreditation Board for Education and Training (NABET), Quality Council of India (QCI).

B. S. Envi-Tech (P) Limited (BSET) expresses its sincere Thanks to the Management of Bhavan's Vivekananda College, Sainikpuri, Secunderabad for assigning the work to carry out the **"Green Audit"** of the Bhavan's Vivekananda College.

During the process of the Audit, BSET found that the Management, Faculty and Students of the College were committed towards conservation of Environment and the same is reflected in implementation.

Our Sincere Thanks to:

- ***Prof Y Ashok – Principal of the College***
- ***Dr Jyothi Nayar – HOD Genetics and Biotechnology***
- ***Dr Y Aparna – Asst. Professor, Microbiology***
- ***Mrs. S Vanitha – Asst Professor, Biochemistry***

and the staff of Bhavan's Vivekananda College for the cooperation and support during the conduct of Green Audit

2.0 Introduction

Kulapathi Dr. K. M. Munshi founded Bharatiya Vidya Bhavan on 7 November 1938 with the blessings of Mahatma Gandhi. Over a period, Bhavans has grown into a secular, apolitical, cultural, and educational organization. It has around 367 constituent institutions, 119 centers in India and 8 centers overseas. About 22,000 members have committed themselves to the Bhavan's ideal " *Vasudhaiva Kutumbakam* " (The World is One Family) and lives by its code.

Bhavan's Vivekananda College (BVC) was established in 1993 under the aegis of Bharatiya Vidya Bhavan, Mumbai and has completed twenty-seven years of reckonable service in the field of higher education. The College is located at Sainikpuri, Secunderabad, Telangana- 500094.

The college enjoys the status of being Autonomous, has been accredited with 'A' grade by NAAC and is placed among the top 200 colleges in the country NIRF Ranking for the consecutive three years 2018, 2019 and 2020. The college has truly emerged as a hub of academic excellence and as the cynosure of academic and research activity and at the same time not lagging in extracurricular and co-curricular activities.

The College is in a sprawling and sylvan 10-acre campus in a prime area of the city; its teaching and supportive departments are accommodated in seven (7) separate buildings with a total plinth area of 1.43 lakh Sq.ft. The college is an Autonomous College and affiliated to Osmania University.

The infrastructure and other facilities in the College are exceptionally good and adequately support the teaching–learning process for 3651 students studying in 15 UG programs, 5 postgraduate degree programs and 2 PhD programs.

The dedication of the management and the college community, combined with excellent infrastructural and teaching facilities help maintain high standards in curricular and co-curricular spheres of the institution. It offers an ideal vision of education that is aware of, and responsive to, the challenges of an emerging India in a globalized world, by bringing in a positive difference in the socioeconomic-educational status of the state and the nation.

2.1 Overview of the College

The details of the infrastructure of the college is given below:

Details of Infrastructure

a) Classrooms/ Classrooms with ICT facilities: 63/55
b) Laboratory (All Science groups): 32
c) Library (both UG & PG): 01
d) Seminar hall and Auditorium: 4
e) Sports room: 1
f) Gymnasium: 1
g) Staff and students parking area: Yes.
h) Canteen: 2
i) Polyhouse:1

List of Buildings,

a) Commerce Block
b) I.T Block
c) PGDM Science Block (Biochemistry)
d) North Block (Examination)
e) West Block (Science Block)
f) MBA Block
g) Library Block (New Block)
h) Vivek Bharati Stage
i) Physical Activity Room (Gym Building)
j) Canteen
k) Scooter Stand
l) Sports Storeroom

Departments

1. Mathematics and Statistics
2. Physics and Electronics
3. Computer Science
4. Commerce
5. Genetics & Biotechnology
6. Biochemistry
7. Chemistry
8. Languages
9. Microbiology
10. Economics

11.Mass Communication
12.Political Science
13.Management Studies

Courses Offered

UG Programmes

BCA

B.Sc. Physical Science

- B.Sc. (Mathematics, Physics, Computer Science)
- B.Sc. (Mathematics, Statistics, Computer Science)
- B.Sc. (Mathematics, Electronics, Computer Science)
- B.Sc. (Hons.) - Data Science

B.Sc.(Life Sciences)

- B.Sc. (Microbiology, Biochemistry, Chemistry)
- B.Sc. (Microbiology, Genetics, Chemistry)
- B.Sc. (Biotechnology, Genetics, Chemistry)
- B.Sc. (Microbiology, Nutrition & Dietetics, Chemistry)

B.Com

- B.Com (Generals)
- B.Com (Computers)
- B.Com (Hons)
- B.Com (Hons) - Business Analytics

B.A (Mass Communication, Political Science, Economics)

B.B.A

PG Programs

- M.Sc. Computer Science
- M.Sc. Microbiology
- M.Sc. Biochemistry
- MBA
- M.Com

Ph.D. – Microbiology and PhD - Biochemistry

The Following are the details of the Students and Staff (2019-20)

Students

There are **3651** students in the college pursuing Undergraduate / Postgraduate / PhD programs.

Full time Staff / Part time Staff

Teaching staff :**129** / Technical staff :**18** / Nonteaching staff: **35** /Gardner **01**

Outsourced Staff

Security:**10** / Housekeeping: **31**

3.0 PRE-ENVIRONMENT AUDIT

A pre-audit meeting provided an opportunity to reinforce the scope and objectives of the audit and discussions were held on the practicalities associated with the audit. This meeting is an important prerequisite for the green audit because it is the first opportunity to meet the college team and understand various aspects.

The meeting was held in the Chambers of the Principal of the College, Bhavans Vivekananda College, Sainikpuri on 11th February 2021. The meeting was an opportunity to gather information that the audit team can study before arriving on the site. Actual planning of audit processes was discussed in the pre-audit meeting.

Commitment of the Management

The Management has shown keen interest in the audit. The Management has undertaken various eco friendly activities involving the students like tree plantation programs, eco friendly Ganesh idol making, operation of vermicompost, pollution check of vehicles in the campus, Green Chemistry etc. The management is keen to implement the findings of the green audit.

Audit Objective

A clean and healthy environment aids effective learning and provides a conducive learning environment. There are various efforts around the world to address environmental education issues. Green Audit helps an academic institution in Identifying the Environmental issues and suggest various measures both short term and long term to achieve the goal of conservation of Environment, biodiversity, and energy management.

The present Green Audit of Bhavans Vivekananda College, Sainikpuri was conducted with the help of structured checklists, walk through audits, sampling, and measurement of environmental parameters like Ambient Air Quality, Water quality, Noise levels etc.

Detailed discussions were held with the Principal and Faculty of the college on various issues including review of documents/historic data furnished by the management.

Benefits of the Audit

The following are the benefits of the Green Audit.

- More efficient resource management
- To provide basis for improved sustainability
- To create a green campus.
- To enable waste management through reduction of waste generation, solid- waste and water recycling
- To create plastic free campus and evolve health consciousness among all the stakeholders.
- Impart environmental education through systematic environmental management approach and improving environmental standards of the Campus.
- Benchmarking for environmental protection initiatives.
- Financial savings through reduction in resource use.
- Inculcating a sense of individual and social responsibility for the College and its environment.
- Enhancement of college profile by developing an environmental ethic and create a system of practical understanding of the complex issues relating to Environment and Climate Change.

Target Areas

The following Target areas have been included in this green audit.

a. Land use analysis using Remote Sensing imagery, Green Belt development
b. Water & Wastewater,
c. Storm water Management
d. Rainwater Harvesting
e. Solid Waste
f. Hazardous Waste
g. Energy Consumption and Conservation
h. Pest Control
i. Transport
j. Ambient Air Quality
k. Water Quality
l. Ambient Noise.

Methodology of Green Audit

Audit Stage

The Auditing was carried out by the BSET team and involving the teaching and non-teaching staff of the College.

The green audit began with the formal introductory meeting with the Principal and Faculty members. A walk-through audit of the campus was undertaking by the BSET team and Senior Faculty of the College. The team conducted the walk-through audit of various facilities at the college like water system, electricity systems, wastewater management, solid waste management, housekeeping, parking area, stormwater system, rainwater harvesting, landscaping DG sets, Roof top solar systems etc.

Discussions were held with the College staff to obtain the details of usage, frequency, or general information of the target areas. A detailed checklist was shared with the College team for information and data. It was agreed to use the data for the year 2019 since one complete year data set was available.

Sampling for environmental parameters of Ambient Air Quality, Water Quality, Noise levels etc. was done by BSET team and the analysis was carried out the BSET Analytical laboratory.

College records and documents were reviewed to clarify the data received through survey and discussions during the Audit. The whole process was carried out during the period February -2021 to March 2021.

Audit Participants

On behalf of the College

- Prof Y Ashok – Principal of the College
- Dr Jyothi Nayar – HOD Genetics and Biotechnology
- Dr Y Aparna – Asst Professor, Microbiology
- Mrs. Vanitha – Asst Professor, Biochemistry

and other staff.

On Behalf of BSET

Mr. Y B S Moorthy - Managing Director and EIA Coordinator, ISO – 14001 Certified Auditor (BE (Mech.), PG – Energy Management)

Mr. K Srinivas — Indian Green Building Council Accredited Professional, CQI & ICRA Certified Lead Auditor in ISO 9001–2015, ISO 14001–2015 & 45001 – 2018 (BE. (Civil), MBA, PG Diploma in Env. Studies)

Mr. V. Vijay Kumar – Senior Environment Scientist (M.Sc. – Environmental Science, M.Tech – Environmental Management)

Mrs. P. Himakranthi – Senior Environment Engineer (M.Tech – Environmental Management)

Mr. Edukondalu - Environment Scientist (M.sc – Environmental Science)

The Management, Principal and the Staff of the College have undertaken many Environment Conservation Activities involving the students at the College.

The following are some of the areas undertaken by the College Management and Students

a) Tree plantation programs,
b) Eco friendly Ganesh idol making and distribution to locals through ***greENERGY*** club of the College.
c) Operation of vermicompost,
d) Traffic Awareness and Pollution check of vehicles in the campus,
e) Implementing Green Chemistry in the laboratories etc.
f) Implementation of 30kWp Roof top solar plant.
g) Publishing Papers related to Green Practices in Scientific Journals.
h) Eco friendly bamboo hut has been constructed near the canteen.

Monitoring of Environmental Data

The following Environmental Parameters were monitored in the campus to establish the baseline conditions:
Land Use Land Cover using Remote Sensing Satellite Imagery
Ambient Air Quality (AAQ) comprising Particulate Matter (PM10) and (PM2.5), SOx, NOx
Water Quality for Drinking Water Quality Standard IS 10500
Noise Level Survey

Review of Policies

Discussions were made with the college management regarding their policies on environmental management. The college has developed inhouse policies for disposal of e-waste, pest management, housekeeping of the campus infrastructure and used paper etc. The management has already implemented good energy conservation practices like replacing old tube lights with LED lights, purchase of Air conditioners with BEE Star rating which is commendable.

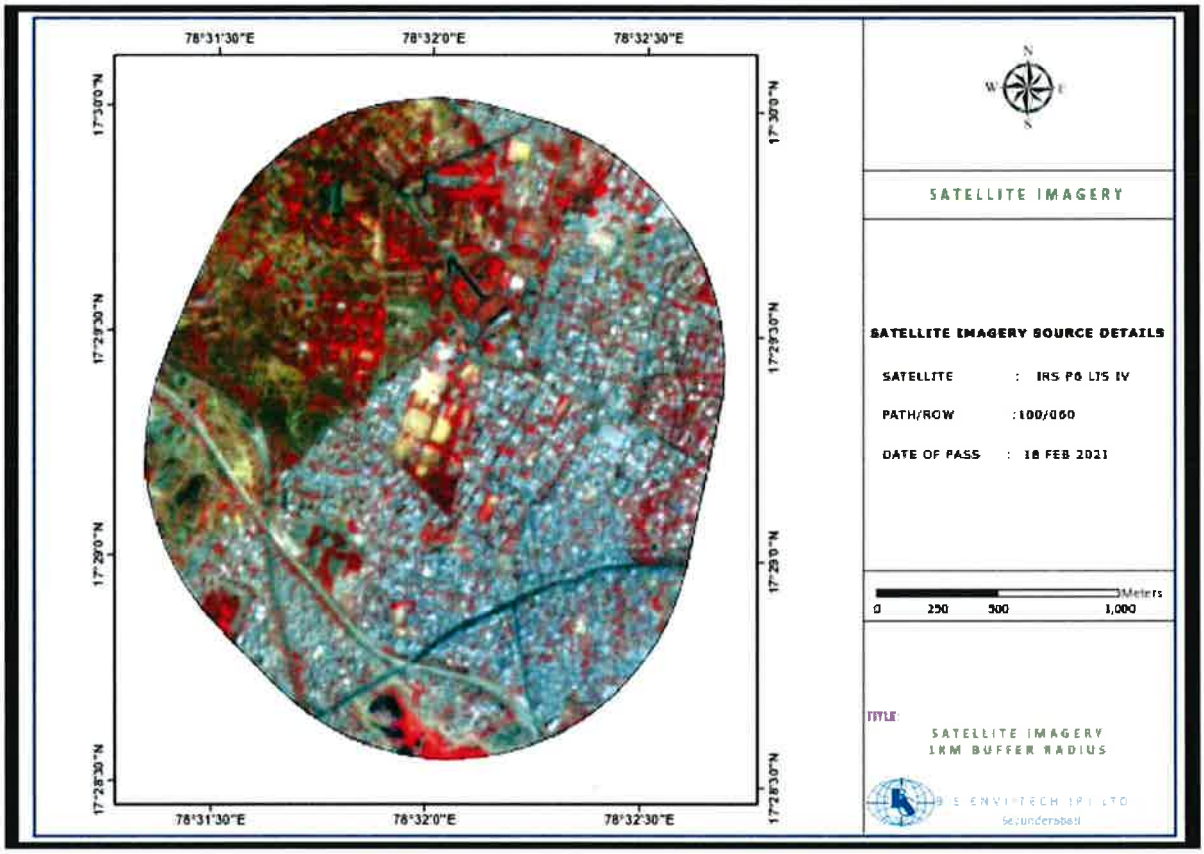
The College has formulated a **Green Policy**. **(Annexure -1)**

4.0 Post Audit Stage

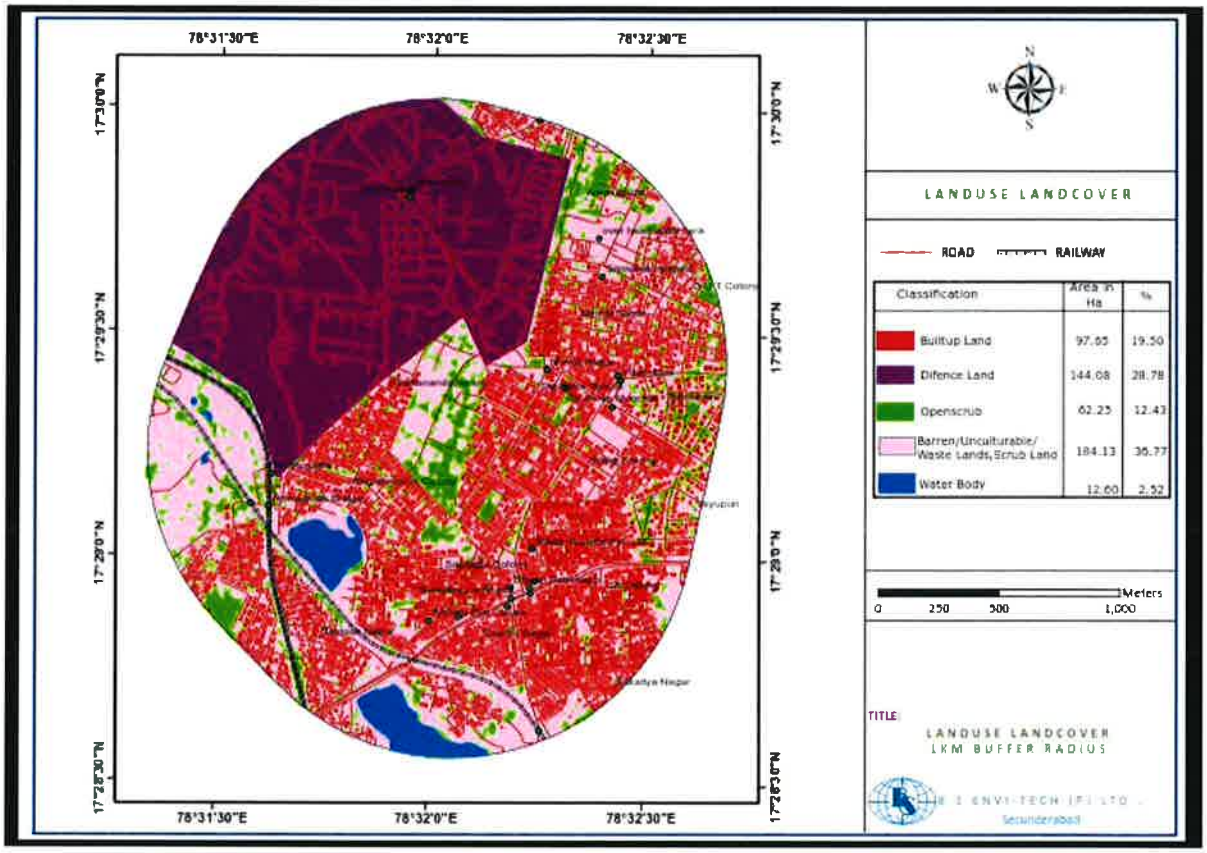
Key findings and Observations

LAND

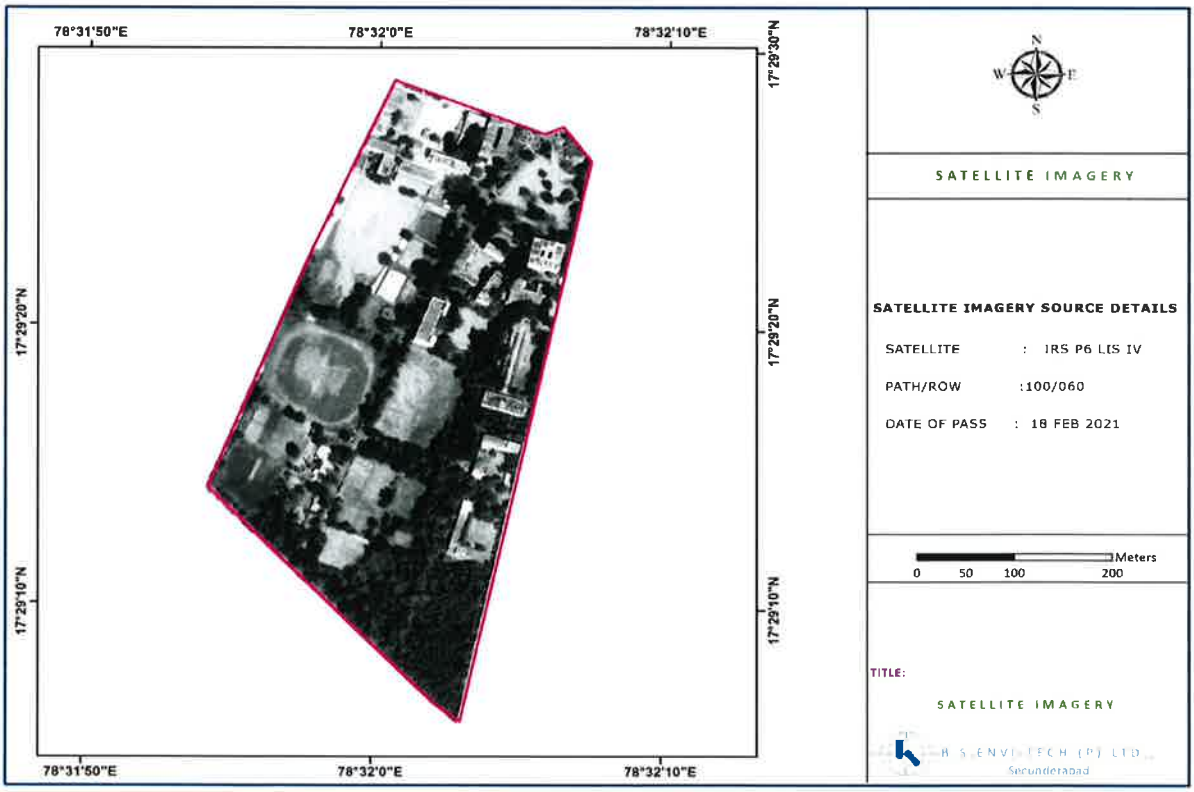
The Bhavans Complex has three Institutions namely School, Junior College and Degree & PG College located in a total area of about 50 acres. However during discussions it was noted that the present area of the campus is 43 acres. The Land use and Land cover using the IRS P6, LIS IV Remote Sensing Satellite Imagery is given below:



REMOTE SENSING IMAGERY OF THE SITE



INTERPRETED IMAGE OF THE LAND USE



It is noted that the Bhavans Vivekananda College is in an area of about 10 acres, for which this Audit has been carried out.

The buildings constructed in the campus of Bhavans Vivekananda College have a total built up area of **143,117.50 Sq.ft (13,296 Sq.m)** as per the details given in Table below.

Built Up area

S. No	Block	No. of Floors	Built up Area (Sq.ft)
1	Commerce block	G+01	16,338
2	I.T block	G + 03	35,945
3	PGDM Science block	G +02	13275
4	North block	G +01	4,680
5	West block	G +01	11,776
6	MBA block	G +03	31,527
7	Library block (New block)	G +02	22,825
8	Vivek Bharati stage	G	2,150
9	Physical activity (Gym)	G	4,601
	Total		1,43,117.50

Green Belt

The college has nearly 78 different plant species that includes ornamental plants, potted plants, shrubs, herbs, trees, and grass. During the audit all the trees were counted and tagged,

The campus is lush green with trees rich in medicinal values, such as Neem, Areca palm, Bottle brush, Bauhinia, Cassia, Delonix, Jacaranda, Tecoma, Tabebuia, Cymbopogoncitratus, Emblica, Lagerstroemia, Ocimum gratissimum, Mimusopselengi.

The overall Bhavans campus has a lush Greenery predominantly on the Southern side of the site as depicted in the Remote sensing imagery.

The management encourages the students and staff to participate in tree plantation programs regularly on the campus. The College has recently participated in Govt. of Telangana scheme **"Haritha Haram."**

The List of Plant Species grown within the Campus are given in below:

S.No	Scientific Name	Common Name
1	Acalypha circinata	Jacob's Coat
2	Acalypha hispida	Cat's Tail
3	Acalypha macrophylla	Heart Copperleaf
4	Acalypha tricolor	Copper Leaf
5	Achras sapota	Chikoo
6	Aegle marmelos	Golden Apple
7	Allamanda cathartica	Golden Trumpet Vine
8	Allamanda violacea	Violet Allamanda
9	Aloe barbadensis	Aloe Vera
10	Alstonia scholaris	Scholar Tree
11	Alternanthera bettzickiana	Calico Plant
12	Araucaria heterophylla	Norfolk Island Pine
13	Artabotrys odoratissimus	Green Champa
14	Azadirachta indica	Neem
15	Bambusa bambos	Indian Thorny Bamboo
16	Bauhinia blakiana	Hong Kong Orchid Tree
17	Bauhinia racemosa	Bidi Leaf Tree
18	Bougainvillea glabra	Paperflower
19	Bougainvillea spectabilis	Great Bougainvillea
20	Butea monosperma	Flame of the Forest
21	Caesalpinia pulcherrama	Peacock Flower
22	Callistemon speciosus	Bottle Brush
23	Calotropis gigantea	Giant Milkweed
24	Carica papaya	Papaya
25	Caryota mitis	Fishtail Palm
26	Cestrum nocturnum	Night Blooming Jasmine
27	Chlorophytum glaucum	Scaly-Stem Chlorophytum
28	Chrysalidocarpus lutescens	Areca Palm
29	Crotolaria trifolia	Rattlepod
30	Cycas revolute	Sago Palm
31	Cyperus alternifolius	Umbrella Flatsedge
32	Delonix regia	Flame Tree
33	Dieffenbachia seguine	Dumb Cane
34	Dracaena fragrans	Corn Plant
35	Dracaena marginata	Dragon Tree
36	Dracaena reflexa	Song of India

37	Dracaena sanderiana	Lucky Bamboo
38	Duranta erecta	Sky Flower
39	Echeveria agavoides	Molded Wax Agave
40	Eucalyptus sideroxylon	Black Ironbark
41	Euphorbia milii	Christ Plant
42	Ficus religiosa	Peepal
43	Furcraea gigantea	Giant Cabuya
44	Hibiscus rosa-sinensis	Chinese Hibiscus
45	Ixora chinensis	Red Ixora
46	Ixora duffii	Giant Red Ixora
47	Ixora singaporensis	Flame of the Woods
48	Jatropha curcas	Physic Nut
49	Jatropha pandurifolia	Peregrina
50	Lagerstroemia indica	Common Crape Myrtle
51	Lantana camara	Lantana
52	Leucaena leucocephala	Wild Tamarind
53	Livistonia rotundifolia	Round-leaf Fountain Palm
54	Mangifera indica	Mango
55	Michelia champaca	Champa
56	Millingtonia hortensis	Indian Cork Tree
57	Mimusops elengi	Maulsari
58	Moringa oleifera	Drumstick Tree
59	Neolamarckia cadamba	Kadam
60	Nerium odorum	Oleander
61	Nyctanthes arbor-tristis	Har Singar
62	Peltophorum pterocarpum	Copperpod
63	Phyllanthus emblica	Indian Gooseberry
64	Plumeria alba	West Indian Jasmine
65	Polyalthia longifolia	Ashok
66	Pongamia pinnata	Pongam Tree
67	Prunus dulcis	Almond
68	Psidium guajava	Guava
69	Rosa indica	Indian Fragrant Rose
70	Spathodea campanulata	African Ttulip Tree
71	Syzygium cumini	Jamun
72	Tabernaemontana coronaria	Crape Jasmine
73	Tabernaemontana variegate	Pinwheel Jasmine
74	Tamarindus indica	Tamarind
75	Tecoma stans	Yellow Bells
76	Terminalia catappa	Indian Almond
77	Thuja orientalis	Morpankhi
78	Thunbergia erecta	King's Mantle

Solid Waste Management

The Solid Waste generated from the campus is split into the following categories.

1. Organic waste (Food waste from canteen)
2. In-organic waste (papers, bottles, cans, boxes, plastic etc.,)
3. Leaf Litter, twigs, branches etc.

The details of the wastes generated from the campus during the year 2019-20 are as follows:

Details of Waste	kg/annum
canteen waste	1500
Green Litter	1300
Non-Biodegradable	900

There was no landfill of the green litter and canteen waste during the period January 2019 to December 2019.

The campus has provided three sanitary napkin incinerators in the washrooms.

The picture showing blue color apparatus is the incinerator and adjacent picture is its dispenser.

The college has recycled 6,275 kgs of used/wastepaper (white paper, newsprint, colored paper & cardboard) during the year 2019-2020. The used papers are given to ITC, Ltd for paper recycling and as pay back, fresh papers are supplied by ITC to the college.

Leave, twigs etc. are dried and Vermicomposting done. The obtained compost is used as manure for the plants.

Non-biodegradable waste collected from the college areas is carefully taken up by the GHMC for its proper disposal and further recycling.

Students are advised not to waste food. The food waste from the canteen is sent to this Vermi composting pits and the compost is utilized for Green Belt Development.

With the initiative taken by canteen authorities, use of thermocol plates, paper plates/steel plates and paper cups, paper covers have minimized the quantum of non-biodegradable wastes.

About 110 kg of waste was composted within the college campus which consists of 70kg cow dung and 40 kgs of leaf litter.

The college also has developed vermicomposting pits to teach the students about the Vermi compost Process. The students are taught the practical aspects of Vermi composting as part of Course Curriculum.

The other solid waste generated in the college campus is disposed off to GHMC and the cost incurred is Rs 2,500 per month.

FOOD

Food services are outsourced in the Campus. Segregation of dry and wet waste is done by placing separate bins at various points within the campus.

CANTEEN WITH WASTE BINS

The following are the programs implemented in the college campus to promote source reduction for minimization of waste, especially Paper.

1. Implementation of double-sided printing and copying to lessen the burden of printout papers used.

2. Papers printed on one side are again used for taking prints on the other side for rough drafts or drafts prepared for verification before the final document could be taken.
3. Conduct of online Placement Eligibility Test (PET exam) for UG and PG students, and continuous internal exams (CIA) for PG students are conducted online to create energy conservation steps to reduce the bulk consumption of paper.
4. The examination branch has duplex printers. This enables the complete usage of paper on both the sides.
5. As an initiative taken to make ZERO use of plastic, posters for National Seminars organized by the departments of Commerce, Biochemistry and Microbiology, all the participants were advised and encouraged to perform their presentation as e-posters.

HAZARDOUS WASTE

DG Sets

The College has two DG sets of 30 kVA (MBA Block) and 15 kVA (IT Block) capacity. The maintenance of the DG Sets is given to a third party, which takes care of replacement of used lube oil, soaked cotton etc.

The used batteries of Uninterrupted Power Supply (UPS) systems are given under a buy back scheme with the Battery suppliers.

LABORATORY CHEMICALS

The College has implemented Green Chemistry practices to minimize the usage of Hazardous chemicals. The details of the same are given in **Annexure -2**

E WASTE

The E waste generated from the College consists of tube lights, LED Bulbs, used computers which are unserviceable, monitors, laptops, used lab equipment having electronics etc.

The college has a tie up with Third party Agency (M/s Envirocare Recycling Solutions Private Limited, Hyderabad) for handling **E-Waste.**

The Methodology of disposal of the E Waste adopted by the College is given below:

a) A write-off committee consisting of the Principal and 2-3 senior staff members are responsible for disposing computers, office/laboratory equipment that cannot be repaired.

b) Few of the unused computers are used by the lecturers from the department of Computer science as models to explain the hardware components and their functions to the students, which is a part of their curriculum.

Computer IT hardware classes using the discarded computers

WATER MANAGEMENT

Water Consumption

The total water requirement of the campus comprising three institutions is met through Municipal water (HMWSSB) and one Bore Well.

The details of water consumption (municipal water) by the college campus during the period January 2019 – December 2019 is given in the table below

Date	Water Used (KL)	Amount Paid (Rs.)
02/01/2019	722	97,531.00
02/02/2019	753	101,722.00
02/03/2019	804	108,604.00
02/04/2019	849	114,679.00
02/06/2019	784	105,904.00
02/07/2019	839	113,328.00
02/08/2019	831	112,249.00
02/10/2019	616	83,220.00
02/11/2019	516	69,720.00
02/12/2019	772	104,283.00

The Campus has One Bore well and is operated for about 3 hours in a day.

There is no separate metering for the three institutions. Hence the bill is proportionately divided based upon the student's strength. Similarly there is no metering on the output side. i.e usage by each institution

The consumption of water for Educational Institutions as per National Building Code (NBC 2016) is given below:

Details	No. of persons	Domestic (Liters/ Day)	Flushing (Liters/ Day)	Total (Liters/ Day)
Students	3651	91275	73020	164295
Teaching Staff	129	3225	2580	5805
Technical Staff	18	450	360	810
Nontechnical Staff	35	875	700	1575
Outsource Staff	42	1050	840	1890
Total	3,875	96,875	77,500	174,375

It may be observed from the above table that the design per capita consumption (NBC-2016) is 45 liters per student per day i.e. 1,170 Liters per student per Month (considering 26 days per month).

The average consumption as apportioned with the help of water works bills is about 748 KL per month, which works out to 192 Liters per student per month, which is well below the design requirement as per NBC - 2016.

Proper care is taken regarding maintenance to ensure there is no leakages from taps, pipes, and valves. Random checks are done regularly by the college authorities.

RAINWATER HARVESTING

The Campus has a total of 22 No.s of Rainwater Harvesting Pits. These pits are maintained and cleaned periodically to prevent silt accumulation, and the efforts have paid rich dividends to the college.

The Campus currently has one no. Bore well, which is in operation.

The Project has well designed Storm water drains, which collect the storm water from the higher elevation of the Campus and the storm water is discharged to the natural drain outside the campus.

Rainwater Down Take Pipes.

Some of the Buildings have Rain water Down Take Pipes, but not all are connected to the Rain water harvesting pits.

WASTEWATER

The wastewater from the buildings is collected and sent to the nearest Septic Tank. The septic tanks do not have soak pits and it has been informed by the management that they will engage the services of an external agency for cleaning the septic tank.

The Liquid waste generated from the canteen is connected to a drain system.

The left-over water collected from the distillation unit is cooled and used for gardening purposes.

Wastewater from the laboratory is diluted and with proper care is disposed of.

Chemicals involving release of fumes are opened or handled inside a fume hood available in the department of Chemistry lab.

PEST CONTROL

M/s Safety Pest Control Services, Secunderabad are handling the pest control activities in the Campus as per the Agreement dated 01.11.2020. The pesticides are used both indoors and outdoors. The Spraying of the pesticides are undertaken after the college hours.

The college is using bio-pesticide like Neem Oil.

Frequency of the spraying- Once a week. 1st, 3rd, and 4th Saturday – Spraying is done in external areas and on 2nd Saturday – Spraying is done within the classrooms. Diluted Neem Oil is used as a natural pesticide.

As a part of the curriculum (Skill Development Course) life sciences students are actively involved in learning and participating in activities related to pest management.

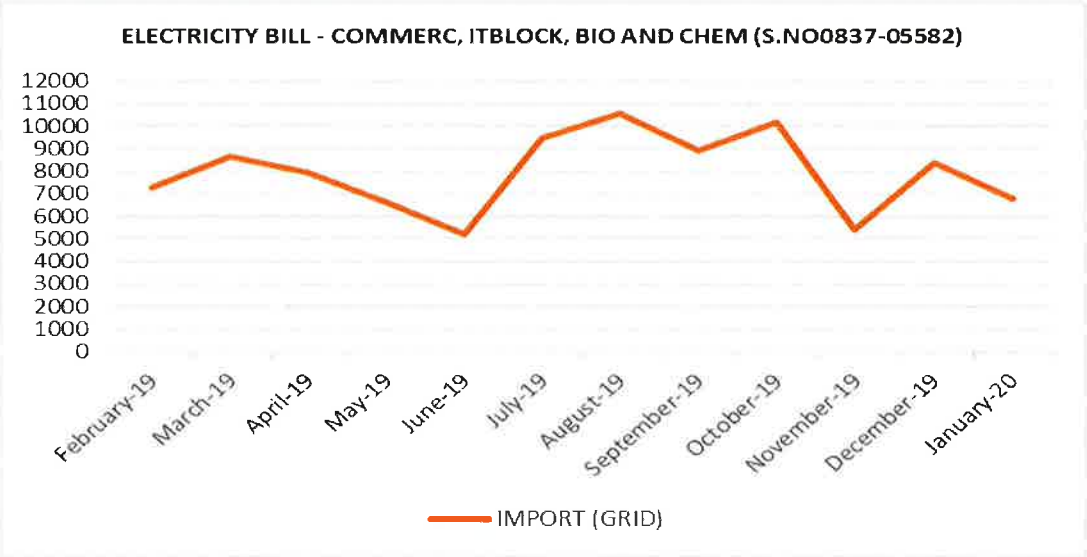
ENERGY CONSUMPTION

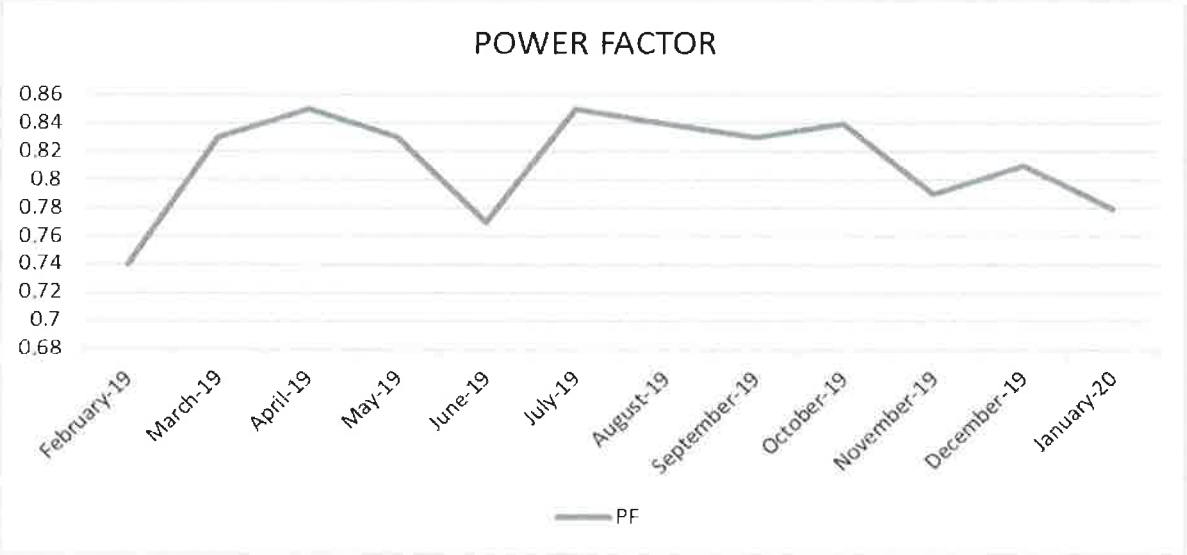
GRID POWER:

The campus has implemented the following energy conservation/awareness programs.

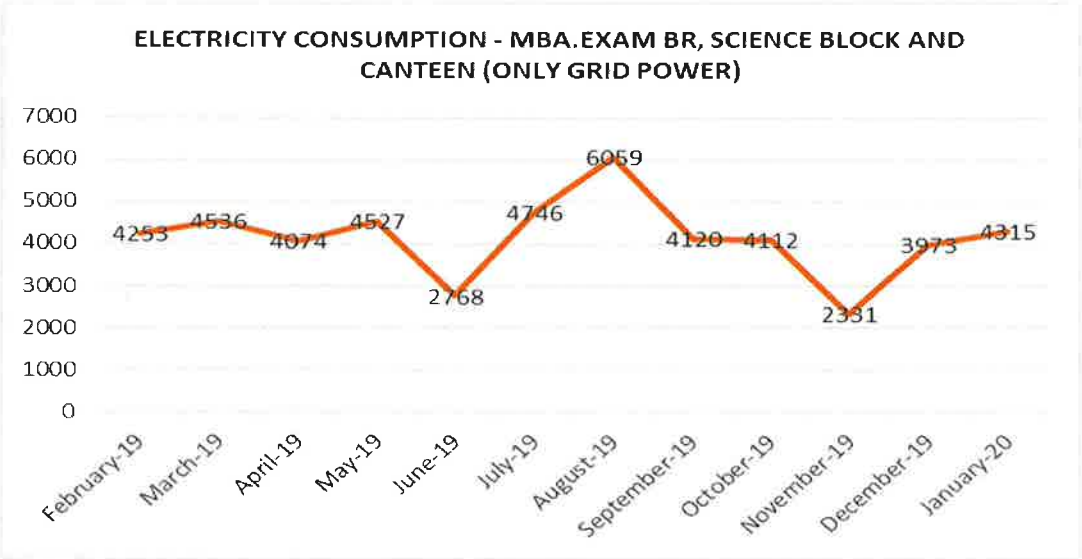
- Installation of Solar panels (30kWp Roof Top Solar Panel) on the IT Block building.
- Use of LED bulbs
- Awareness program in the form of various activities like guest lecture, seminar etc.
- Environmental studies as an AECC course for the students is being offered as a part of their curriculum.

The college has two service meters. The details of the Electricity consumption and export of power from the Roof top Solar plant during the period February 2019 to January 2020 is given below:

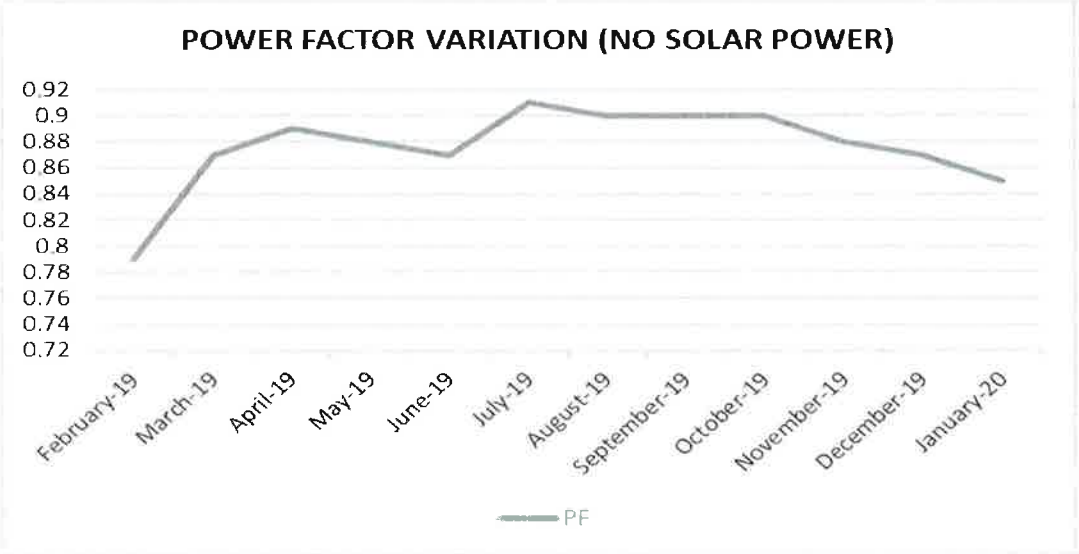




It may be observed from the above graphs that the Power Factor of the system which has Roof top solar plant has lower PF (< 0.85) which needs to be checked. By improving the PF the electricity bill amount can be reduced.



The total electricity purchased from the grid as per this meter is 49814 kWh and the monthly average consumption is 4151 kWh.



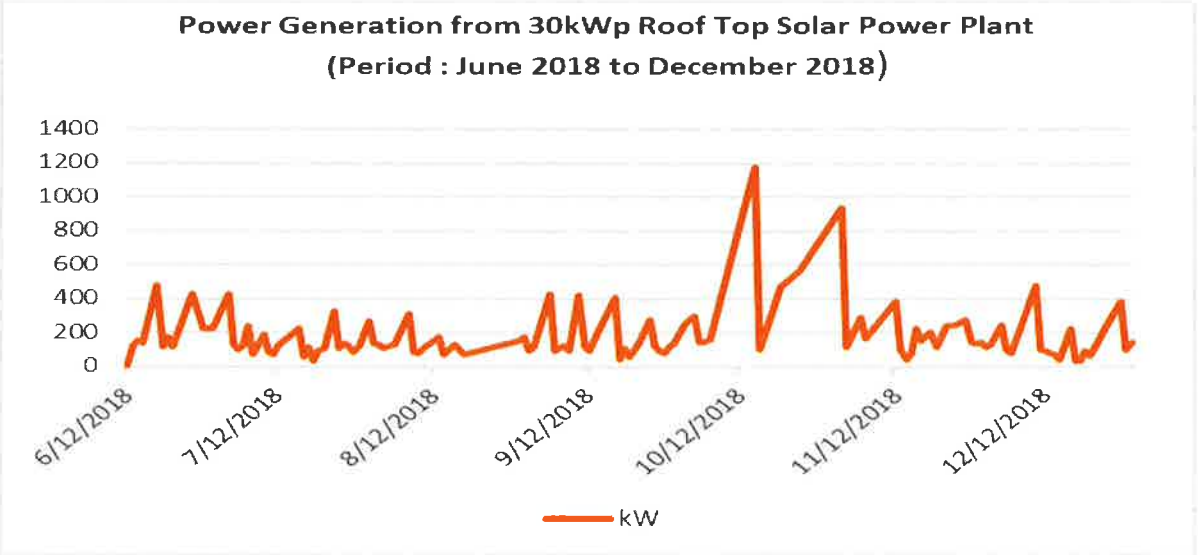
RENEWABLE ENERGY (30KWP ROOF TOP SOLAR POWER PLANT)

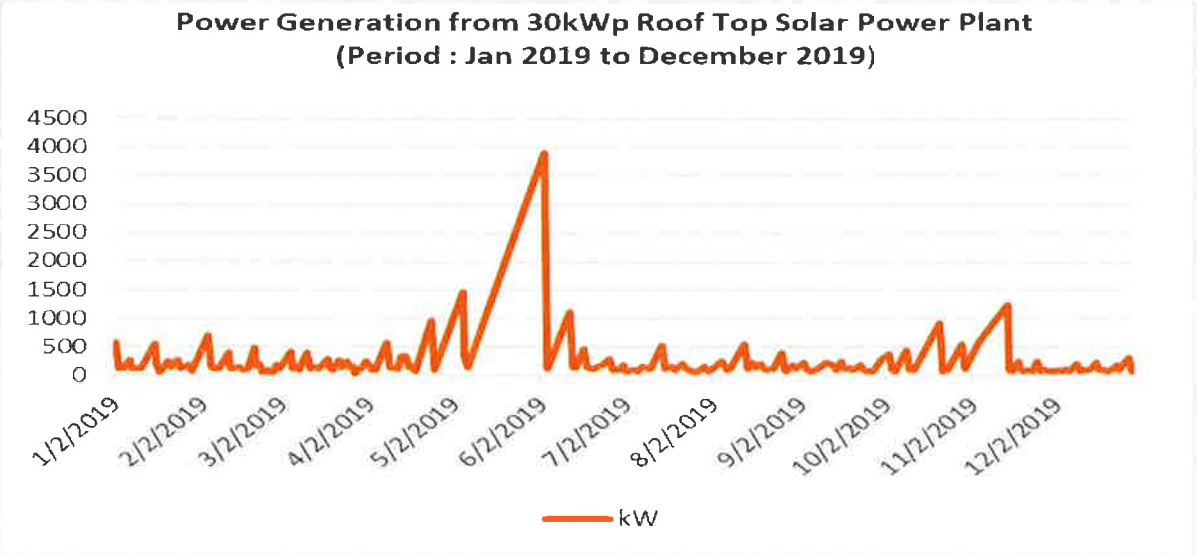
GRAPH SHOWING ELECTRICITY GENERATION (EXPORT) FROM 30 kWp ROOF TOP SOLAR PLANT FOR THE PERIOD (May 2018 to Till Date)

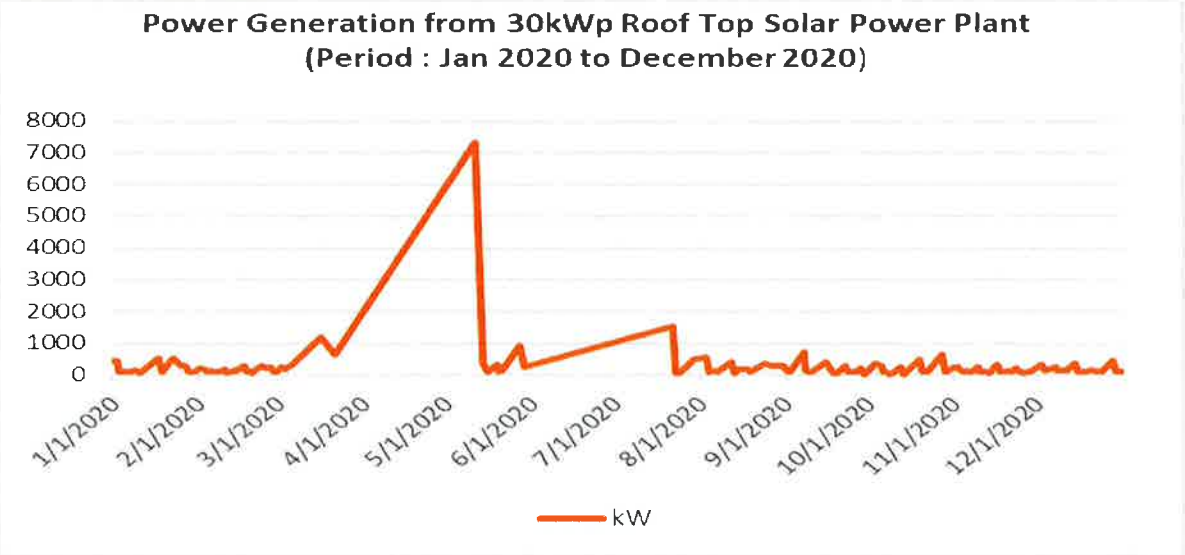
The College had implemented a 30 kWp Roof top solar power plant in the month of May 2018. The year wise generation electricity from the Roof top solar power plant is represented graphically and the total power generation till date is summarized below:

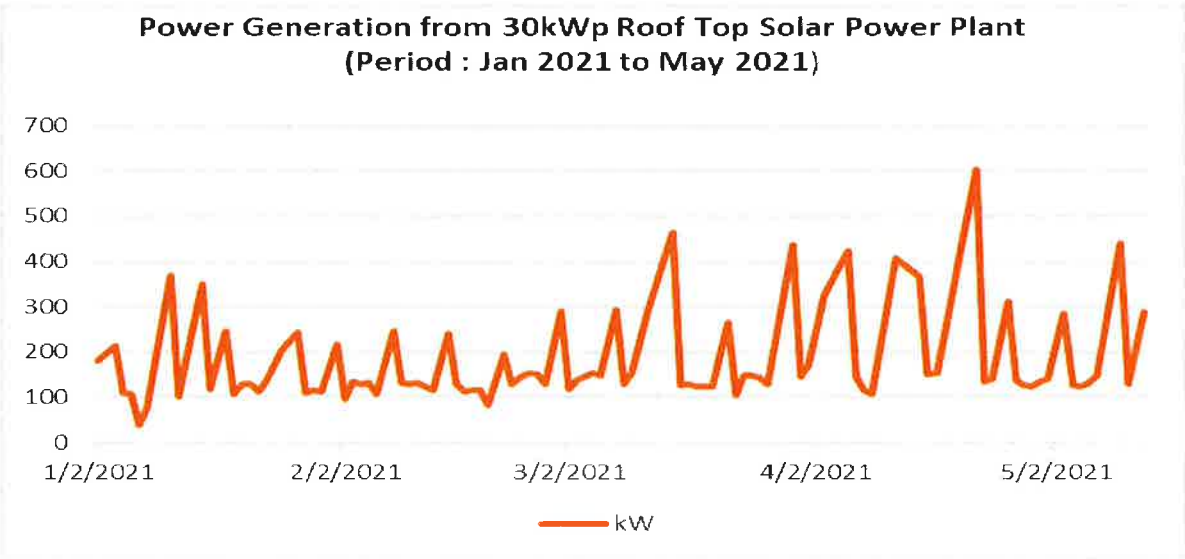
Power Generation from 30 kWp Roof Top Solar Power Plant	
2018	21572
2019	44467
2020	44355
2021 - Till date	17140
TOTAL	1,27,534

The total electricity purchased from the grid during the year 2019 is 1,45,415 kWh. The total power generated from the 30kWp roof top solar power plant is 44,467 kWh which is 30.57% of the purchased electricity.


Power Generation from 30kWp Roof Top Solar Power Plant
(Period : June 2018 to December 2018)
1400
1200
1000
800
600
400
200
0
6/12/2018
7/12/2018
8/12/2018
9/12/2018
10/12/2018
11/12/2018
12/12/2018
kW


Power Generation from 30kWp Roof Top Solar Power Plant
(Period : Jan 2019 to December 2019)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1/2/2019
2/2/2019
3/2/2019
4/2/2019
5/2/2019
6/2/2019
7/2/2019
8/2/2019
9/2/2019
10/2/2019
11/2/2019
12/2/2019
kW





The Details of Tube lights, Fans, AC's, Motors for pumping Water etc are given below:

1	Lighting Population -Number of lighting fittings	Watt	Quantity
a.	Incandescent		
b.	Fluorescent Tube Lights (FTL)	40 W	606
c.	Compact Fluorescent Lamp (CFL)	-	-
d.	Sodium Vapor Lamp (SVL)	-	-
e.	Metal Halide Lamp (MHL)	-	-
f.	Mercury Vapor Lamp (MVL)	-	-

g.	Halogen Lamps (HL) STREET LIGHT	100,72,32 W	30
h.	TUBE LIGHT LED	20W	132
2	Fans		
a.	Wall mounting Fans	100 W	5
b.	Ceiling Fans	100 W	591
c.	Table Fans	100 W	2
d.	Exhaust Fans	60 W	92
3	**Total Number of Computers with CPU**	384	
4	**Total Number of UPS**	22	
5	**Motor Pumps**		
a.	Number of pumps in the plant (Approx)	10 No. (1 Borewell)	
b.	Number of continuous running pumps and their capacity	10 No.	
6	**Air Conditioning & Refrigeration**		
a.	Total no of A/C plants and Capacity.	No	
b.	Split A/C Units and Capacity	15 N0. 1.5 capacity	

Transportation

Modes of Transport used by Staff/Students (19-20)

Mode of Transport (2019-20)						
Course/Mode of Transport	**Bicycle**	**Public Transport**	**By Walk**	**Two-wheeler /car**	**Vehicle pooling 4-wheeler**	**Vehicle pooling 2-wheeler**
UG I	16/1106	555/1106	83/1106	259/1106	5/1106	56/1106
UG II	7/1045	436/1045	69/1045	267/1045	3/1045	52/1045
UG III	13/960	364/960	51/960	301/960	3/960	69/960
PG I&II	4/532	203/532	18/532	132/532	1/532	23/532
Ph. D	0/8	0/8	0/8	1(8)	0/8	0/8
Teaching staff and Technical staff	0/147	13/147	9/147	79/147	6/147	9/147
Non-teaching staff	0/67	18/67	15/67	31/67	0/67	0/67
TOTAL	40/3865	1589/3865	245/3865	1070/3865	18/3865	209/3865
OVER ALL PERCENTAGE	**1.03%**	**41.11%**	**6.33%**	**27.70%**	**0.50%**	**5.40%**

The above data was collected by the college using an online survey for which 82% of the total students and staff have responded. The College does not have a bus facility; however about 41.11% of the students and staff depend on Public Transport.

The college is not conducting verification of Pollution Check certificates of the vehicles of the Staff and Students. However, the ***greEnergy club*** is conducting awareness camps with the help of RTA certified mobile pollution check vans.

TRAINING AND AWARENESS PROGRAMS

The college conducts training programs, seminars, workshops for sensitizing students and staff for Energy Conservation and Environment Management
Topics related to pollution, biodiversity, government and non-government agencies duties and responsibilities were taught to students as a part of their curriculum "Environmental studies" to bring awareness on the environment and its sustainability.

List of ecofriendly activities being conducted in the campus.

- Planting and caring of trees in and around the campus.
- Timely disposal of wastes from the campus.
- Celebration of important days like World Environment Day, with great importance.
- Proper handling of solid waste, e waste and hazardous waste

On-site sampling of Environmental Parameters

Ambient Air Quality

The ambient air quality was monitored by establishing PM2.5 and PM10 samplers near the Science block. The monitored values are well within the NAAQ standard. The detailed Analysis reports are given in **Annexure-3**.

Water Quality

The quality of Borewell water and the HMWSSB supply water were analyzed. The water samples are in conformity with IS10500 standard. The borewell water has Fluoride content which is marginally higher (1.92 as against limit of 1.5 mg/l). This water is being used for gardening purpose only. The detailed Analysis reports are given in **Annexure-4**.

Ambient Noise level Quality:

The spot noise levels were monitored at various locations within the campus and found to be in the range of 53.9 to 64.8 dBA. The test report is attached as Annexure-5.

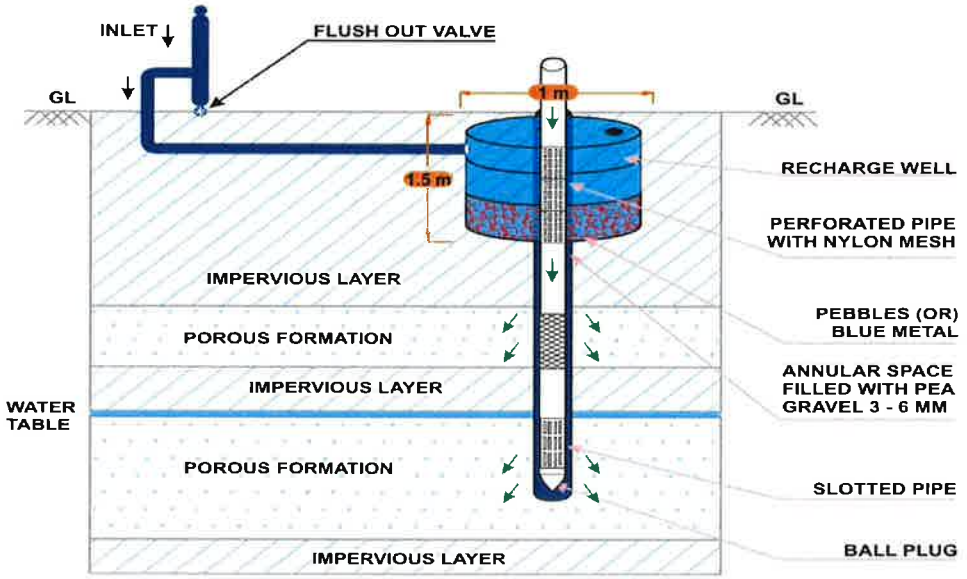
5.0 Consolidation of Audit Findings

Major Audit Findings

- The Management has taken up various environmental issues with the cooperation of the staff and students which is appreciable.
- The housekeeping of the sprawling campus is good.
- The College has developed a Green policy statement indicating the commitment of the college towards its environmental performance.
- The installation of solar panels, training in vegetable cultivation and composting practices are appreciable.
- The college can increase the number of display boards (in open spaces or in the verandahs) using eco-friendly material like gypsum boards etc on various topics like climate change, Water conservation, Air pollution etc. These will enthuse the students strolling in the campus and will disseminate the information/knowledge.
- The Campus has good green cover. It can further be developed in a scientific manner all along the periphery of the compound wall which will act as dust and noise barriers. It will also be a component to reduce GHG emission.
- The students can be given the task of enumeration of the tree cover in the campus using Google Earth and geotagging the photos of the trees. This will be an elaborate exercise which will inculcate the importance of Climate Change and the reduction of CO_2 gas which is the major greenhouse gas.

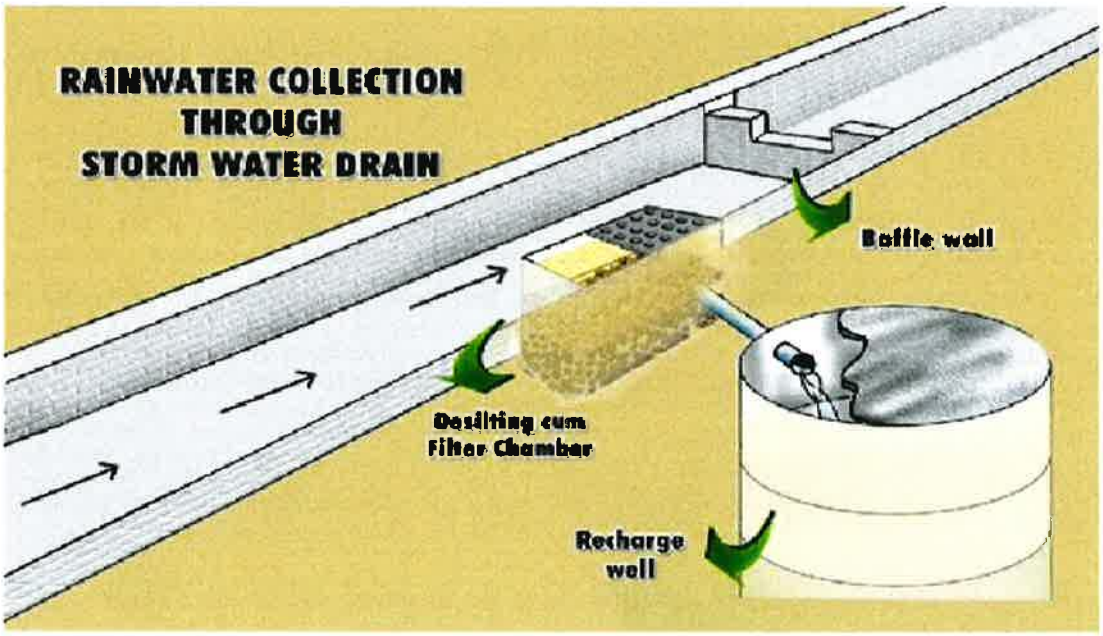
Water Audit

- Individual meters for all the three campuses may be implemented which will give the correct consumption of water instead of apportioning the bill based on number of students.
- The water consumption is less when compared to NBC 2016 standard, but individual metering will bring out clarity in water consumption.
- The downcomer pipes of the roof tops shall be connected to the Rainwater harvesting pits. Regular maintenance of the pits is required to increase the recharge capacity. The following diagrams show the proper design of rainwater harvesting pits.



- The storm water channels shall be cleaned regularly and maintained wherever the stone pitching has been damaged. Tree plantation can be taken up on either side of the storm water channel.

- Baffles can be provided in the storm water drain to increase the recharge of ground water. The following schematic shows the use of a baffle and pumping the surplus stormwater to a nearby rainwater harvesting pit.



Energy Audit

- The communication process for awareness in relation to energy conservation is good.
- The College has implemented the following energy conservation measures which is commendable:
  - A) Roof top solar PV system of 30 kWp
  - B) Implementation of LED bulbs and BEE 3* / 5* Star rated Air conditioners
  - C) The college has established a policy of shifting to energy efficient lights like LED bulbs

The College shall undertake the following replacement policy during regular maintenance:

a) *Halogen lamps to be converted to LED lamps.*
b) *Tube lights to be converted to LED tubes /CFL without ballasts.*
c) *Energy Efficient fans which will consume about 30watts.*
d) *Review of the power factor of the IT Block where in the Roof top solar has been connected* in consultation with Roof top solar plant supplier.

The typical savings are as follows:

- ✓ *Halogen Lamps - reduction of 70 watts from 100 watts (existing) to new units consuming 30 Watts.*
- ✓ *Tubelight – Reduction of about 20 watts savings from 40 watts(existing)*
- ✓ *Energy Efficient Fans – about 50% less from standard fans.*

The college has outsourced the maintenance of DG sets to a third party which takes care of the regular maintenance. The DG sets are having acoustic enclosures.

The amount spent on diesel for the two DG sets is as follows:

a) *30 kVA DG set – Rs 58000/- (805 liters of diesel @ Rs72/- liter)*
b) *15 kVA DG set – Rs 57250/- (795 liters of diesel @ Rs 72/- liter)*
c) *Average no of hours of operation of the DG sets is 140 hrs/DG set.*

Based on the above data the total quantity of diesel consumed by the two DG sets is 1600 liters/ annum.

Replace older computers and TVs with LED systems which will consume less power.

A brief note on PF improvement, Energy Efficient Fans, Energy Conservation in Schools prepared by Bureau of Energy Efficiency are enclosed as **Annexures 6,7 and 8.**

Greenhouse Gas Emissions/ Carbon footprint

A study was undertaken to prepare a preliminary estimate of the GHG emissions based on the data collected for the year 2019. The Carbon footprint was estimated using the Simple Corporate Environment Inventorisation tool of the India GHG Programme. The estimate has not considered the transport aspect since the data on the fuel consumption of individual students/staff was not available. The college can involve the students in this exercise to understand the Carbon Footprint estimate. A brief note on GHG Emissions is given in **Annexure -9.**

The summary of the findings of the Carbon Footprint of the College is given below:

Table 1

Scope 1	6.7	MT CO2 eq.
Scope 2	119.2	MT CO2 eq.
Total	126.0	MT CO2 eq.

Table 2

Total Emissions (Grid Power)	155.7	MT CO_2.eq
Offset/Avoided Emissions (Solar Power)	36.5	MT CO_2.eq
Net Emissions	119.2	MT CO_2.eq

It may be observed from Table 1 that the total emissions under Scope 1,2, protocol excluding emissions contribution of transport (College does not have its own buses) is 126.0 MT CO_2.eq. It may be inferred from Table 2 that the purchase of Grid power has contributed about 155.7 MT CO_2.eq The Roof top solar plant of 30 kWp has provided an offset of 36.5 MT CO_2.eq. The Net emissions is 119.2 MT CO_2.eq due to purchase of Grid power.

This can further be brought down by implementing the following:

a) Energy conservation methods
b) Additional Roof top solar plants for other buildings in the campus

c) Increasing the greenery by greenbelt development

It may be interesting to note that Mr. Chepuri Sridhar Rao, SFS District Forest Officer, Siddipet had estimated the Carbon Sequestration benefits of the trees within the campus as per standard protocol. An amount of 1925.25 kg of carbon di oxide has been sequestered by 17 species of trees identified by their girth, height, and biomass inside the campus. This works out to about 1.925 MT of CO2 sequestered by the Trees. With this the Net emissions further reduces to 117.325 CO_2 eq.

Awareness on Carbon Consumption

- Students and Staff members may be made totally aware of pollution caused by use of vehicles.
- The Greenhouse Gas Emissions , Climate change awareness, programs on carbon footprint of transportation, greenery development will bring awareness in the students on the importance of energy conservation, waste minimization etc. both at individual as well as societal level.

Waste Audit

- The college has implemented segregation of food waste in the canteen. Proper bins are provided for collection and disposal. The food waste is sent for composting.
- The College has tied up with ITC Ltd for disposal of used paper. ITC in turn supplies Fresh paper which is commendable.
- The tree litter etc. is being composted.
- The College has introduced Green chemistry thereby eliminating use of any hazardous chemicals.

Green Campus Audit

- Tree cover of the college is good. As per the Remote Sensing Satellite imagery, the Southern side of the campus is predominantly green. The college can take up further development of green belt all along the periphery of the Compound wall. The typical greenbelt development can

be done as per the following schematic.

TREE PLANTING ZONES
Native Species should be planted

- Display boards to all plants identified can be developed and these can be photographed and geo-tagged on Google Earth. This exercise by the students will improve their knowledge level and understanding of the benefits of trees in terms of supplying the Oxygen and absorbing the CO_2.

- The College can plan an ***ARBORETUM*** (**Arboretum**, place where trees, shrubs, and sometimes herbaceous plants are cultivated for scientific and educational purposes) in the college campus.

- Encouraging students to develop Nests for Sparrows and other birds. Help can be sought from Dr Vasudev Rao Vaidyula, Principal Investigator, PJTS Agricultural University who has co-authored the Telangana State Bio-Diversity Field Guide. https://www.researchgate.net/profile/Vasudeva-Rao-Vaidyula.

- It will be good idea to maintain a Registry for flora and fauna on the campus. This can be done by involving agencies like Deccan Birders, Wildlife India:

  DECCAN BIRDERS (Formerly AP Birdwatchers Society)
  Email ID:
  deccanbirders@gmail.com

Telephone:
994 903 8532 : Surekha Aitabathula (Hon. Secretary)
984 922 9552 : M Shafaat Ulla (Past Hon. Secretary)

WILDLIFE INDIA – Hyderabad Office
Ms. Farida Tampal
State Director
WWF-India Hyderabad Office
H.No: 1-2-288/42,
Plot No 21, 1st Floor S.B.H Colony,
Domalguda, Gaganmahal,
Hyderabad - 500 029
Telangana
Tel: 040-23394151 / 52/ 53

Email : ftampal@wwfindia.net

- Developing a model Herbal Garden. For this one can arrange a visit to PRAGATI RESORTS (https://pragatiresorts.com/). A detailed note on PRAGATI RESORTS is enclosed as **Annexure – 10.**

Environmental Education

The following environmental education program may be implemented in the college before the next green auditing: -

- Training programs in solid waste management, liquid waste management, setting up of medicinal plant nursery, water management, vegetable cultivation, tree planting, energy management, landscape management, pollution monitoring methods, and rainwater harvesting methods.
- Increase the number of display boards on environmental awareness such as - save water, save electricity, no wastage of food/water, no smoking, switch off light and fan after use, plastic free campus etc.
- Establish more Student Groups under the ***greEnergy club*** with a designated tasks like tree plantation, waste management, GHG emissions computations, Flora/Fauna studies of the campus etc.
- Conduct exhibition of recyclable waste products.

Common Recommendations

- Conduct more seminars and group discussions on environmental education through guest lectures, involving agencies like Wildlife India etc. and visit to

CII Green Building which is Asia's Net Zero energy building:

- **CII - Sohrabji Godrej Green Business Centre**
  Survey # 64, Kothaguda Post
  R R District, Hyderabad - 500084
  India
  Tel: +91 40-44185111 (B)
  Fax: +91 40 44185189
  E-mail: gbc@cii.in

Criteria Wise Recommendations

Water

> It is better to install separate water meters to monitor the consumption.
> The downcomer pipes of rainwater must be connected to the nearest rainwater harvesting pit.
> The following activities can be taken up for the storm water drains.
  a) Undertake repairs of the drains,
  b) Develop plantation on either side of the drain.
  c) Install RCC baffles in the storm water drain.
> Awareness programs on water conservation to be conducted.
> Install display boards on interesting topics of water conservation.

Energy

> Employment of more solar panels and other renewable energy sources.
> Conduct more save energy awareness programs for students and staff.
> The Management can initiate a replacement policy with energy efficient lights, fans etc. It is commendable that the Management has procured BEE Star rated Air conditioners for the College.
> Regular cleaning of the A/Cs before the onset of Summer will improve in energy saving.
> All the A/Cs can be set at 27°C temperature and use of Fans can be encouraged which will save power.

> Observe a power saving day every year.

Waste Management

- The college has implemented good waste management practices.
- The students should be encouraged to develop more display boards on various Environment/Climate Change topics for information dissemination.

Green Campus

> All trees in the campus should be named scientifically, geotagged using Google Earth.

> Undertake greenbelt development on the periphery of the compound wall.

> Create automatic drip irrigation system during summer holidays.

> Beautify the college building with indoor plants which can act as Pollution Absorbers.

> Conducting competitions among departments for making students more interested in making the campus green.

6.0 Conclusion and Recommendations

An outside view through an external audit will often help the Management and staff of the College to review the problems or methods and see the value of alternative approaches for greening the Campus.

A green audit report is an immensely powerful and valuable communications tool to establish baseline status, review the projects undertaken and cross-pollinate ideas for further improving various aspects like energy conservation, improving greenery etc. The sole idea is to inculcate the importance of environment and climate change to the young minds and sensitize on the important topics like air pollution, Climate Change etc.

Photographs

Storm water Drain


VIVEK BHARATHI

Bio Chemistry Block

IT Block

Library Facilities

- Central Library & 10 Departmental Libraries

Roof Top Solar Plant – 30 kWp

Green House

Staff Parking

Students Parking

Rainwater Harvesting Pit

ACTIVITIES TAKEN UP BY THE COLLEGE

The details of the activities taken up by the College are given below:

Sale of Green Ganesha (2012-13)

Haritha Haram program:

Tree Plantation 23rd July 2016

GreEnergy club, NCC unit and NSS unit of the college jointly organized Tree Plantation Program as part of Haritha Haram project of the Telangana Govt. in the college premises. A total of 300 saplings were planted in the college Campus. The whole program was actively carried out by the students and staff of the college led by the Principal, Prof. Y. Ashok, and Heads of the Departments. Air Comdr. J. L. N Sastry, (Retd.) VSM, Vice Chairman BVB, Sainikpuri Kendra and Col M. Vijay Rao, Hon Dir BVC, Sainikpuri also planted trees as part of the programme.

2019-20

Environmental Promotional Activities

Tree Plantation Programme

Six days orientation program for First year students all post graduate program of 2019-2021 batch, have taken part in a tree plantation program, arranged by the GreEnergy club of the College. Dr Jyothi Nayar, HoD, Dept of Genetics and Biotechnology coordinated this program. Faculty from PG departments of Biochemistry, Microbiology, Computer Science, MBA and MCom along with new batch of students have taken part in this program very enthusiastically and planted good number of plants. This event created environmental concern amongst students and appreciated by everyone.

Pollution Check- Report (2019-20)

The greENERGY club of the Department of Genetics & Biotechnology organized 'Pollution Check' for two and four wheelers. The event was organized on 8th February, 2020 with an objective to educate the vehicle owners on the importance of pollution control. Both students and staff who commute to college by their own two & four wheelers supported the event by getting their vehicles checked for pollution. The club coordinated with the nearby RTA approved pollution check agent and completed the task. The program was a great success owing to the large number of vehicles checked for pollution. A total of 144 vehicles belonging to staff & students were checked. The enthusiasm and hard work of the members of the gre-ENERGY club is greatly appreciated.

Plogging Report

Bhavan's Vivekananda College organised an event on plogging (which is a combination of jogging and picking up plastic and waste) in the campus under the supervision of Dr. Jyothi Nayar, Head, Department of Genetics and Biotechnology, on 7th December, 2019 from 2.30 p.m. to 3.30 p.m.

170 students from various streams like NSS, NCC, YRC, Sports and Guides participated in the event picking and gathering only plastic. It started with the introductory note by Dr. Jyoti Nayar followed by a demonstration given by student volunteers that educated participants about the advantages of plogging which included exercise as well.

All the students were divided into four groups and each group was assigned plogging to various parts of the college namely Canteen, parking lots, College entrances and washrooms. The students were instructed to bring gunny bags to collect the plastic wastes. They were anxiously engaged in cleaning the campus and the team spirit they carried is to be appreciated.

After completing plogging, they approached the student volunteer assigned to weigh the collected plastic and ended up collecting 69kgs after which, all were instructed to deposit the bags with plastic in the area which will be cleared by the municipality. The students dispersed with a sense of satisfaction that they contributed their time and effort for the cleanliness of the College Campus.

Workshop on Plogging

Reports for various activities organized and conducted under Environmental Studies

Head of Department: Dr C Kameswari
Lecturers in-charge: 1) Ms Prachi Nath
2) Ms M Anila
3) Ms Prasitha Haridev

Plogging Workshop by Ripu Daman Bevli – Plogman of India – on 30 September 2019

"PLOGGING" means Cleaning up your surroundings while exercising your body physically. Ripu Daman is a solo traveller, entrepreneur, athlete and a devoted plogger. He has been dedicatedly and selflessly working on cleaning up our nation and making the citizens responsible to clean up while they are out for a walk, for the past two years. He inspired the students to trend the Hash tag "#PlasticUpvaas" which bans the use of single-use plastic including straws. His mission statement – "Clean up other people's litter" emphasizes on cleaning up the litter around us irrespective of whom it belongs to.

Report on Guest Lecture on "Energy Conservation" 21st December, 2019

As a part of National Energy Conservation week celebrations that is from 14th December to 20th December, COPES (Centre of Plant Engineering Services) in association with Bhavan's Vivekananda College has organized a awareness programme on "Energy Conservation" on 21st December,2019.

Dr. Balaiah Sir from COPES addressed students on "How and why to do energy conservation?". Sir stressed on providing to students and staff about simple tips of conserving energy at home and also at our workplace. The topic focused on need for conservation also. Conserving energy in industry, market, academy, residence, agriculture was also addressed by the speaker.

Guest Lecture by Mrs. Medha Naniwadekar

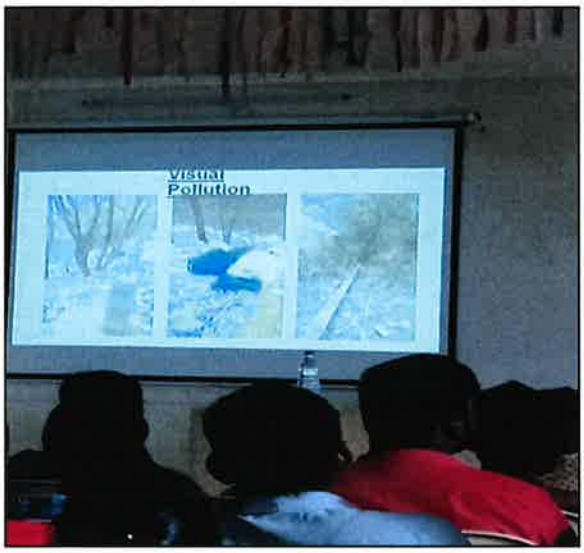
Reports for various activities organised and conducted under Environmental Studies

Head of Department:	Dr C Kameswari
Lecturers in-charge:	1) Ms Prachi Nath
	2) Ms M Anila
	3) Ms Prasitha Haridev

A series of interactive guest lectures were conducted by Mrs. Medha Naniwadekar – an architect by profession but an environmental activist by choice and passion. The lectures were attended by BSc final year students and first year UG students.

Mrs. Medha Naniwadekar has been associated with Swachh Bharat and Palle Srujana since last 7 years. Her lectures comprised a very effective PowerPoint Presentation with graphic pictures taken across India and abroad, illustrating the glaring contrast in the cleanliness conditions. She projected the poorly maintained tourist destinations in India, focusing on the garbage littered everywhere. She also discussed about the clogging of drains and sewers by solid wastes and discarded waste that lead to blockage and a resultant overflow onto the streets, bad odour and consequent ill-health. She also spoke about the problem of manual scavenging in India.

Mrs Medha motivated the students to take responsibility for their actions by inculcating the habit of fenko matt – Not to throw garbage in public areas, and also to educate others. She encouraged the students to sing and dance along with her on her theme song – Fenko MaTt. The students were highly motivated and inspired by her zeal and passion towards cleanliness, and promised to follow her guidelines.



ECOFEST 2020 – Report (17th & 18th January, 2020)

The greEnergy club of the Department of Genetics & Biotechnology, Bhavan's Vivekananda college of Science, Humanities & Commerce, Sainikpuri, organized ECOFEST on 17th and 18th January, 2020. The concept for Ecofest 2020 was "Go Green". The objective of this program is to synchronize with nature, conserve and appreciate our planet.

The event was presided by the Principal Prof. Y Ashok, Vice Principal Mrs B Niraimathi and Dr Jyothi Nayar, Head, Department of Genetics & Biotechnology and Coordinator of greEnergy Club.

Various competitions were organized as part of the two-day fest:

1. Rangoli competition – with the traditional rangoli powder sans colors.
2. Innovative Tagline – based on environmental issues / nature.
3. Photography - Bhavan's Fauna (animals in the campus)
   The purpose of the event was to encourage and spread awareness towards the animal community existing in the college campus, owing to the presence of the vast diverse flora.
4. Quiz competition – based environmental issues/nature
   Preliminary round was based on MCQs on Environmental Science in which 18 teams participated. Ten teams were selected for the final round. It was a pictorial quiz where students had to identify the pictures depicted in the slides.

The judges for the events were

1. Rangoli - Mrs Rita

2. Innovative tagline – Mrs Madhuri Mathur

3. Bhavan's Fauna – Mr Shiva Trishul

The fest was fruitful owing to the enthusiastic participation from 127 participants. The prize winners of the various events are as follows:

- Rangoli competition
  Ist prize: M. Sai Chitra & Anima Kashyap (MBiC II Year)
  IInd prize: Monika Septa (BtGC III Year)
  B. Janaki Sai Priyanka (MGC III Year)

- Innovative tagline
  Ist prize: D. Sowjanya (MBiC III Year)
  IInd prize: Monika Septa (BtGC III Year)
  IIIrd prize: N. Janavi (BtGC I Year)

- Bhavan's Fauna
  Ist prize: M. Shanvanth Doha (BtGC II Year)
  IInd prize: T. Sravya Manasa (BtGC II Year)
  IIIrd prize: Md Qudrathullah Khan (BtGC III Year)

- Quiz Competition
  Ist prize: K.G. Gayatri & Tanya Sharma (MGC II Year)
  IInd prize: Richa & Anima Kashyap (MBiC II Year)

Campus Clean-up Drive

Reports for various activities organised and conducted under Environmental Studies

Head of Department: Dr C Kameswari
Lecturers in-charge: 1) Ms Prachi Nath
2) Ms M Anila
3) Ms Prasitha Haridev

Target Group: Semester I students

Campus Clean-up Drive: a series of campus clean-up drives were conducted during July 2019, the purpose of which was to discourage students from littering their surroundings. The students enthusiastically went around the campus with bags, and collected plastics, majority of which were empty water and cold drink bottles of different sizes, Multi-layered plastics (chips packets), and tetra-packs.






Awareness programme

Report on National Seminar "Eco-friendly strategies for Sustainable Environment"

Faculty of Life Sciences of Bhavan's Vivekananda College organized a National Seminar on "Eco-friendly strategies for Sustainable Environment" on 28th and 29th February, 2020. The seminar was structured to celebrate National Science Day under DBT-Star College Scheme. Environmental sustainability is a fundamental requirement

to avoid depletion and degradation of natural resources. Developing effective strategies for maintaining the balance in natural environment is the need of the hour. The chief guest of the seminar was Prof. K. Janardhan Reddy, Regional Coordinator of Telangana Academy of Sciences, Hyderabad Centre. The Guest of Honour of the event was Prof. Purshottam Reddy (Retd), Political Science Department, OU, Eminent Environmentalist, Academician and Development Activist. The seminar was presided by Sri I.Y.R. Krishna Rao, IAS (Retd.), Former Chief Secretary, Govt. of AP, Chairman, Bharatiya Vidya Bhavan, Sainikpuri Kendra andAir Commodore (Retd), J.L.N. Sastry, VSM, Vice Chairman, Bharatiya Vidya Bhavan, Sainikpuri, Kendra. Welcome address was delivered by Prof Y. Ashok, Principal, BVC. Dr. Madhumita Bhattacharjee, Convenor and Head, Department of Chemistry, BVC, presented the report of the National Seminar. The chief guest for the valedictory was Prof. Shivaraj, Dean, Faculty of Sciences, Development &UGC affairs, OU, Hyderabad. The two-day event comprised of technical sessions by eminent scientist and oral and poster presentation by enthusiastic participants. Participants included students, scholars and faculty from various educational and Research Institutions within and outside Telangana.

The theme was applied appropriately on the first day of the seminar, by releasing the souvenir in a CD (compact Disc) and shared with the participants digitally. Poster and Paper presentation by participants was also through digital mode using LCD projectors. College has taken this initiative to create and implement the strategies in encouraging to adopt the sustainable methods to create a healthy and safe place.

TREE PLANTATION

ANNEXURES

Annexure-1

Bharatiya Vidya Bhavan
(Founded in 1938 by Kulapati Dr. K.M. Munshi)
BHAVAN'S VIVEKANANDA COLLEGE
of Science, Humanities & Commerce
Estd : 1993 AFFILIATED TO OSMANIA UNIVERSITY
AUTONOMOUS COLLEGE
ACCREDITED WITH "A" GRADE BY NAAC
SAINIKPURI, SECUNDERABAD - 500 094. Ph : 27111611, 27115273

Date : 7 - 10 - 20

Green Audit Policy

Bhavan's Vivekananda College of Science, Humanities and Commerce, Sainikpuri, Secunderabad has adopted a 'Green Audit Policy' to develop environmental sustainability in its campus by (a) shifting to renewable energy, (b) protecting the eco system in the campus, (c) avoiding excess pollution, (d)efficient waste management, and (e) integrating other green initiatives.

A. **The Committee:**

(i) There shall be a 'Green Audit Committee' in the college consisting of the following members:

1. Principal of the College ... Chairperson
2. Senior Faculty ... Members
3. Administrative Officer ... Member
4. Student Representatives ... Members

ii) The Principal shall nominate the members at serial numbers (2–4) abovewhose term is for 2 years from the date of nomination to the committee.

(iii) The Committee shall meet once in every 6 months or more often if necessary,to devise strategies for (a) creating awareness among the staff and students on environmental sustainability, (b) monitoring the green initiatives and practices undertaken, and (c) conducting regular audits on Environment, Energy and Green belt.

B. **Strategies for Environmental Sustainability:**

(i) Include 'environmental sustainability' courses in the curriculum of all programs.

(ii) Preserve 30% of total campus area as "Green Area". No construction of buildings shall be undertaken now or in future in this area. Plantation of saplings will be carried out annually to conserve the green belt.

(iii) Proper ventilation to all the buildings to minimise the use of electricity.

(iv) Regular auditing of old buildings to ensure safety and green foot print.

(v) As a 'Go Green' initiative, the segregation and safe disposal of different types of waste generated in the campus are to be strictly monitored, emphasizing on 'Reduce, Recycle and Reuse'.Use of potentially hazardous waste or radioactive waste is to be avoided in the campus.

(vi) Standard Operating Protocols (SoP) to be followed for proper handling and disposal of chemicals.

(vii) Promotes the usage of paperless techniques by adopting e-governance.

(viii) Ensure that all electrical appliances purchased have "Energy Star" rating and their consumption of electricity monitored periodically.

(ix) Implementing alternate sources of energy such as solar energy for effective energy management.

(x) Regular monitoring of Air and water quality to provide safe and secure environment in the campus.

(xi) Prohibit use of plastic in the campus area.

(xii) Restrict the entry of automobiles within the campus to ensure pollution free and safe environment.

****

7/10/20

PRINCIPAL
BHAVAN'S VIVEKANANDA COLLEGE
OF SCIENCE, HUMANITIES & COMMERCE
Sainikpuri, R.R. District-500 094.

NOTE ON GREEN LAB PRACTICES

PREPARED BY DEPARTMENT OF CHEMISTRY, BHAVAN'S COLLEGE

Green Chemistry is an attempt made to minimize the harmful impact of chemicals on the environment by adopting to methods that are inherently non-toxic. The rapid technological development has increased global warming and the chemical industry has a significant contribution to this. The department of Chemistry, Bhavan's Vivekananda College, has taken an initiative to minimize the usage of hazardous chemicals/procedures involving experiments for the undergraduate students. The green methods have been implemented in inorganic and organic analysis. Making changes in our analytical protocol has made an overall impact to make our experiments green while imparting these concepts to students and sustaining the motive of chemical analysis.

SIGNIFICANCE

The inorganic practical syllabus includes semi-micro analysis, where students qualitatively analyze the ions present in the given salt mixture. The analysis involves

i. Identification of certain metal ions that are hazardous.
ii. Use of certain reagents that are hazardous.
iii. Certain procedures that are not eco-friendly.

Therefore, we have minimized or stopped the use/identification of such reagents/metal ions.

Following changes were made in our semi-micro analysis to make our lab course more eco-friendly, while imparting the concept.

1. Nessler's Reagent replaced by Curcumin Solution

Side Effects: Nessler's reagent contains Mercury, which is a heavy metal and it is hazardous. When in direct contact with humans, it causes certain ill effects on inhaling, contact with skin and eye. An average lethal dose for inorganic mercury salts is about 1 gram. When exposed to high limits, may lead to irritation in the mouth, pharynx and eyes, abdominal pain, vomiting and ulcers. Prolonged exposure may lead to vision impairment.

Substituted by: **Curcumin** is an amber colored chemical produced by turmeric (*Curcuma longa*). This is used in the identification of ammonium ions during qualitative analysis.

2. Hydrogen sulphide replaced by Thioacetamide

Side Effects: Hydrogen sulfide is a colorless, highly flammable and explosive gas. Hydrogen sulfide is absorbed through the lungs. Continuous exposure at very low concentration can cause skin allergy and burning of eyes.

Substituted by: Generally, H_2S preparation is a tedious process. An alternate method for using H_2S without fuming the lab is using thioacetamide. In the laboratory, hydrogen sulfide is prepared by hydrolyzing thioacetamide. This method of generating the hydrogen sulfide is very convenient and is used to minimize the presence of the highly toxic and the rotten egg smelling gas in the environment

3. Analysis of heavy metals:

The qualitative analysis also involves the identification of cations from various groups. The cationic analysis includes heavy metals as a part of the analysis. Heavy metals like lead, tin, mercury, antimony, cadmium were usually analyzed. But due to the ill effects of these heavy metals, we have avoided their analysis in the undergraduate chemistry practicals.

4. Discarding the test solutions:

The qualitative analysis involves the use of concentrated acids like sulphuric acid and nitric acid.

We used to dispose of the test solutions into the sink. Disposing these acids into the sink causes corrosion of sanitary ware, pollutes the drainage and ultimately enters the soil.

To prevent this contamination, we modified the disposal procedure. We now collect all the test solutions into a bucket of 10 liters of water and then we check the pH and neutralize it with a base accordingly.

For e.g.: If the collected water has a pH of 5.0, then we need to neutralize it with a base (10% NaOH).

5**. Fume hood:**

Most of the confirmatory tests are done in the fume hood to keep our lab green.

6. Reuse of water collected from the Distillation plant:

All the semi-micro analysis requires distill water to minimize the effect of interference of ions present in the water. In the process of distillation, a lot of left-over water is directly flushed into

the sink. So, as a measure to avoid its waste, rather we reuse the left-over water from the distillation unit by collecting, cooling the collected water and is used to water our plants.

SUMMARY

The revised lab procedures are an attempt to continuously strive to make our lab practices greener. By avoiding harmful chemicals, we are creating a safer environment in the lab and surroundings. These green practices help us to maintain a better lab quality.

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TC-5233

TEST REPORT

Name & Address of the Customer : Bhavans Vivekananda College, Sainikpuri, Secunderabad Telangana **Sample Description:** Ambient Air Quality sample	**Test Report No. :** BSET/2021/AQ-00460 **Lab Code No.** : 211004004 **Issue Date** : 07.04.2021 **Your Ref** : Letter dated 05.04.2021 **Date of Receipt** : 05.04.2021
Qty & Packing : 1 filter paper each for PM_{10} and $PM_{2.5}$, 30ml absorbing solution for SO_2 and NO_2 **Test Required :** As per given below	**Date of Registration** 05.04.2021 **Date of commencement of testing** 05.04.2021 **Date of completion of testing** 07.04.2021 **Sample condition at receipt** Found ok **Sample tested as received**

Sampling Details

Date of Sampling: 03.04.2021 **Location of Sampling:** Near Science Block

General Environment conditions: Ok

TEST RESULTS

Discipline : Chemical
Group : Atmospheric Pollution

S. No.	Test Parameter	Test Method	Result	NAAQ Standards for Industrial,Residential, Rural and Other areas
1	Sulphur Dioxide (SO_2), µg/ m^3	IS:5182 (Part-2)	6.4	80 (24 Hours)
2	Nitrogen Dioxides (NO_2), µg/ m^3	IS:5182 (Part-6)	14.1	80 (24 Hours)
3	Particulate Matter – 10 µm (PM_{10}), µg/ m^3	IS:5182 (Part-23)	63	100 (24 Hours)
4	Particulate Matter – 2.5 µm ($PM_{2.5}$), µg/ m^3	IS:5182 (Part-24)	21	60 (24 Hours)

Make of the Instrument for PM_{10} : Enviro Instruments
Model No : EI-142BL.
Make of the Instrument for $PM_{2.5}$: Enviro Instruments
Model No : EI-133
Duration: :Sample was collected on 24 hourly basis

Authorized Signatory
(G.Chandra Mouli)
Environmental Scientist

••• End of the Report•••

*Complaints Register is available at Laboratory

Note: This report is subject to the terms and conditions mentioned overleaf.

4th Floor, AMITA VILLE, 12-13-1270/1/73, St. Ann's Road, Tarnaka, Secunderabad - 500017, Telangana, India
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ANNEXURE – 4

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TEST REPORT

Name & Address of the Customers : **M/s. Bhavan's Vivekananda College** Sainikpuri, Secunderabad, Telangana -500094	**Test Report No.** : BSET/2021/WS-00457/C **Lab Code No.** : 211004304 **Issue Date** : 15/04/2021 **Your Ref.** : BVC/BSET/WQ/SQ/2021 Dt.05/04/2021 **Date of Receipt** : 05/04/2021
Sample Description : **WATER** **Quantity** : 2 Ltrs + 500 ml **Packing** : Sealed Bottle **Tests Required** : As mentioned below	**Date of Registration** 05/04/2021 **Date of commencement of testing** 05/04/2021 **Date of completion of testing** 15/04/2021 **Sample Condition of receipt** Found Ok **Sample Tested as received**
Date of Sampling : 03/04/2021 **Sampling Method** : IS 3025 PART 1 **Location of Sampling/Sample ID** : Bore well	**Sampling Details** **Environment conditions:** Normal
Discipline : Chemical	**Group** : Water, Residues in water

TEST RESULTS

S.No.	Test Parameter	Units	Test Method	Results	Requirement as per IS 10500 : 2012	
					Acceptable Limit	Permissible Limit in the Absence of Alternate Source
1	Colour	Hazen Units	IS 3025: P 4	< 5	5	15
2	pH value	-	IS 3025: P 11	6.84	6.5-8.5	No Relaxation
3	Turbidity	NTU	IS 3025: P 10	< 1	1	5
4	Total dissolved solids @ 105 C	mg/l	IS 3025: P 16	820	500 Max	2000 Max
5	Total hardness as CaCO3	mg/l	IS 3025: P 21	515	200 Max	600 Max
6	Calcium as Ca	mg/l	IS 3025: P 40	160	75 Max	200 Max
7	Magnesium as Mg	mg/l	IS 3025: P 46	28	30 Max	100 Max
8	Chlorides as Cl	mg/l	IS 3025: P 32	119	250 Max	1000 Max
9	Iron as Fe	mg/l	IS 3025: P53	0.07	1.0 Max	No Relaxation
10	Sulphate as SO4	mg/l	IS 3025: P 24	69	200 Max	400 Max
11	Fluoride as F	mg/l	APHA 23rd Edn 4500 - F, D	1.92	1.0 Max	1.5 Max
12	Nitrate as NO3	mg/l	APHA 23rd Edn 4500-NO3,B	40.9	45 Max	No Relaxation
13	Total Alkalinity as CaCO3	mg/l	IS 3025: P 23	360	200 Max	600 Max
14	Boron as B	mg/l	APHA 23rd Edn 4500 B, B	0.13	0.5 Max	2.4 Max
15	Copper as Cu	mg/l	APHA-23rd Edn 3111 B	< 0.02	0.05 Max	1.5 Max
16	Manganese as Mn	mg/l	APHA-23rd Edn 3111 B	< 0.02	0.1 Max	0.3 Max
17	Zinc as Zn	mg/l	APHA-23rd Edn 3111 B	0.04	5 Max	15 Max
18	Lead as Pb	mg/l	APHA-23rd Edn 3111 B	< 0.01	0.01 Max	No Relaxation
19	Mercury as Hg	mg/l	APHA-23rd Edn 3112 B	< 0.001	0.001 Max	No Relaxation
20	Total Arsenic as As	mg/l	APHA-23rd Edn 3114 C	< 0.01	0.01 Max	No Relaxation

Authorized Signatory
BADRI VENUGOPAL
Quality Manager

Note : this report is subject to the terms and conditions mentioned overleaf.

*Complaints Register is available at Laboratory.

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TEST REPORT

Name & Address of the Customers : **M/s. Bhavan's Vivekananda College** Sainikpuri, Secunderabad, Telangana -500094	**Test Report No.** : BSET/2021/WS-00457/C **Lab Code No.** : 211004304 **Issue Date** : 15/04/2021 **Your Ref.** : BVC/BSET/WQ/SQ/2021 Dt.05/04/2021 **Date of Receipt** : 05/04/2021
Sample Description : **WATER** **Quantity** : 2 Ltrs + 500 ml **Packing** : Sealed Bottle **Tests Required** : As mentioned below	**Date of Registration** 05/04/2021 **Date of commencement of testing** 05/04/2021 **Date of completion of testing** 15/04/2021 **Sample Condition of receipt** Found Ok **Sample Tested as received**
Date of Sampling : 03/04/2021 **Sampling Method** : IS 3025 PART 1 **Location of Sampling/Sample ID** : Bore well	**Sampling Details** **Environment conditions:** Normal
Discipline : Chemical	**Group :** Water, Residues in water

TEST RESULTS

S.No.	Test Parameter	Units	Test Method	Results	Requirement as per IS 10500 : 2012	
					Acceptable Limit	Permissible Limit in the Absence of Alternate Source
21	Sodium as Na	mg/l	IS 3025: P 45	52	-	-
22	Potassium as K	mg/l	IS 3025: P 45	2.0	-	-
23	Total Chromium as Cr	mg/l	APHA-23rd Edn 3111 B	< 0.02	0.05 Max	No Relaxation

End of Report

Authorized Signatory
BADRI VENUGOPAL
Quality Manager

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TEST REPORT

Name & Address of the Customers : **M/s. Bhavan's Vivekananda College** Sainikpuri, Secunderabad, Telangana -500094	**Test Report No.** : BSET/2021/WS-00458/C **Lab Code No.** : 211004204 **Issue Date** : 15/04/2021 **Your Ref.** : BVC/BSET/BQ/SQ/2021 Dt.05/04/2021 **Date of Receipt** : 05/04/2021
Sample Description : **WATER** **Quantity** : 2 Ltrs + 500 ml **Packing** : Sealed Bottle **Tests Required** : As mentioned below	**Date of Registration** 05/04/2021 **Date of commencement of testing** 05/04/2021 **Date of completion of testing** 15/04/2021 **Sample Condition of receipt** Found Ok **Sample Tested as received**
Date of Sampling : 03/04/2021 **Sampling Method** : IS 3025 PART 1 **Location of Sampling/Sample ID** : HMWSSB water	**Sampling Details** **Environment conditions:** Normal
Discipline : Chemical	**Group** : Water, Residues in water

TEST RESULTS

S.No.	Test Parameter	Units	Test Method	Results	Requirement as per IS 10500 : 2012	
					Acceptable Limit	Permissible Limit in the Absence of Alternate Source
1	Colour	Hazen Units	IS 3025: P 4	< 5	5	15
2	pH value	-	IS 3025: P 11	7.42	6.5-8.5	No Relaxation
3	Turbidity	NTU	IS 3025: P 10	< 1	1	5
4	Total dissolved solids @ 105 C	mg/l	IS 3025: P 16	342	500 Max	2000 Max
5	Total hardness as CaCO3	mg/l	IS 3025: P 21	145	200 Max	600 Max
6	Calcium as Ca	mg/l	IS 3025: P 40	42	75 Max	200 Max
7	Magnesium as Mg	mg/l	IS 3025: P 46	9.7	30 Max	100 Max
8	Chlorides as Cl	mg/l	IS 3025: P 32	60	250 Max	1000 Max
9	Iron as Fe	mg/l	IS 3025: P53	0.06	1.0 Max	No Relaxation
10	Sulphate as SO4	mg/l	IS 3025: P 24	55	200 Max	400 Max
11	Fluoride as F	mg/l	APHA 23rd Edn 4500 - F, D	0.65	1.0 Max	1.5 Max
12	Nitrate as NO3	mg/l	APHA 23rd Edn 4500-NO3,B	1.00	45 Max	No Relaxation
13	Total Alkalinity as CaCO3	mg/l	IS 3025: P 23	120	200 Max	600 Max
14	Boron as B	mg/l	APHA 23rd Edn 4500 B, B	< 0.1	0.5 Max	2.4 Max
15	Copper as Cu	mg/l	APHA-23rd Edn 3111 B	< 0.02	0.05 Max	1.5 Max
16	Manganese as Mn	mg/l	APHA-23rd Edn 3111 B	< 0.02	0.1 Max	0.3 Max
17	Zinc as Zn	mg/l	APHA-23rd Edn 3111 B	0.03	5 Max	15 Max
18	Lead as Pb	mg/l	APHA-23rd Edn 3111 B	< 0.01	0.01 Max	No Relaxation
19	Mercury as Hg	mg/l	APHA-23rd Edn 3112 B	< 0.001	0.001 Max	No Relaxation
20	Total Arsenic as As	mg/l	APHA-23rd Edn 3114 C	< 0.01	0.01 Max	No Relaxation

Authorized Signatory
BADRI VENUGOPAL
Quality Manager

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TEST REPORT

Name & Address of the Customers : **M/s. Bhavan's Vivekananda College** Sainikpuri, Secunderabad, Telangana -500094	**Test Report No.** : BSET/2021/WS-00457/D **Lab Code No.** : 211004304 **Issue Date** : 15/04/2021 **Your Ref.** : BVC/BSET/WQ/SQ/2021 Dt.05/04/2021 **Date of Receipt** : 05/04/2021
Sample Description : **WATER** **Quantity** : 250 ml **Packing** : Presterilized Bottle **Tests Required** : As mentioned below	**Date of Registration** 05/04/2021 **Date of commencement of testing** 05/04/2021 **Date of completion of testing** 15/04/2021 **Sample Condition of receipt** Found Ok **Sample Tested as received**

Sampling Details

Date of Sampling : 03/04/2021
Sampling Method : IS 3025 PART 1
Location of Sampling/Sample ID : Bore well
Environment conditions: Normal

Discipline : Biological **Group :** Water

TEST RESULTS

S.No.	Test Parameter	Units	Test Method	Results	Requirement as per IS 10500 : 2012	
					Acceptable Limit	Permissible Limit in the Absence of Alternate Source
1	Total Coliforms	CFU/100ml	IS 1622:1981	Absent	Not Detectable For Treated Water	Not Detectable For Treated Water

End of Report

J. Lakshmi

Authorized Signatory
JULLURI LAKSHMI
Microbiologist

Note : this report is subject to the terms and conditions mentioned overleaf.

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TC-5233

TEST REPORT

Name & Address of the Customers : **M/s. Bhavan's Vivekananda College** Sainikpuri, Secunderabad, Telangana -500094	**Test Report No.** : BSET/2021/WS-00458/D **Lab Code No.** : 211004204 **Issue Date** : 15/04/2021 **Your Ref.** : BVC/BSET/BQ/SQ/2021 Dt.05/04/2021 **Date of Receipt** : 05/04/2021
Sample Description : **WATER** **Quantity** : 250 ml **Packing** : Presterilized Bottle **Tests Required** : As mentioned below	**Date of Registration** 05/04/2021 **Date of commencement of testing** 05/04/2021 **Date of completion of testing** 15/04/2021 **Sample Condition of receipt** Found Ok **Sample Tested as received**
Date of Sampling : 03/04/2021 **Sampling Method** : IS 3025 PART 1 **Location of Sampling/Sample ID** : HMWSSB water	**Sampling Details** **Environment conditions:** Normal
Discipline : Biological	**Group :** Water

TEST RESULTS

S.No.	Test Parameter	Units	Test Method	Results	Requirement as per IS 10500 : 2012	
					Acceptable Limit	Permissible Limit In the Absence of Alternate Source
1	Total Coliforms	CFU/100ml	IS 1622:1981	Absent	Not Detectable For Treated Water	Not Detectable For Treated Water

End of Report

J. Lakshmi

Authorized Signatory
JULLURI LAKSHMI
Microbiologist

Note : this report is subject to the terms and conditions mentioned overleaf.

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CIN No. : U74210TG1999PTC032358

B.S. ENVI - TECH PVT. LTD.

Recognized by MoEF & CC, GoI: Valid upto August, 2022

TC-5233

TEST REPORT

Name & Address of the Customers : **M/s. Bhavan's Vivekananda College** Sainikpuri, Secunderabad, Telangana -500094	**Test Report No.** : BSET/2021/WS-00458/C **Lab Code No.** : 211004204 **Issue Date** : 15/04/2021 **Your Ref.** : BVC/BSET/BQ/SQ/2021 Dt.05/04/2021 **Date of Receipt** : 05/04/2021
Sample Description : **WATER** **Quantity** : 2 Ltrs + 500 ml **Packing** : Sealed Bottle **Tests Required** : As mentioned below	**Date of Registration** 05/04/2021 **Date of commencement of testing** 05/04/2021 **Date of completion of testing** 15/04/2021 **Sample Condition of receipt** Found Ok **Sample Tested as received**

Date of Sampling : 03/04/2021 — **Sampling Details**

Sampling Method : IS 3025 PART 1 — **Environment conditions:** Normal

Location of Sampling/Sample ID : HMWSSB water

Discipline : Chemical — **Group :** Water, Residues in water

TEST RESULTS

S.No.	Test Parameter	Units	Test Method	Results	Requirement as per IS 10500 : 2012	
					Acceptable Limit	Permissible Limit in the Absence of Alternate Source
21	Sodium as Na	mg/l	IS 3025: P 45	52	-	-
22	Potassium as K	mg/l	IS 3025: P 45	2.9	-	-
23	Total Chromium as Cr	mg/l	APHA-23rd Edn 3111 B	< 0.02	0.05 Max	No Relaxation

End of Report

Authorized Signatory
BADRI VENUGOPAL
Quality Manager

Note : this report is subject to the terms and conditions mentioned overleaf.

*Complaints Register is available at Laboratory.

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TEST REPORT

Client	: Bhavans Vivekananda College
Location	: Sainikpuri, Secunderabad, Telangana
Month	: April-2021
Date of Sampling	: 03.04.2021

AMBIENT NOISE LEVEL MEASUREMENTS dB (A)

Station Code	Location	Date	Spot Noise Level dB (A)
N1	Canteen Area	03.04.2021	56.8
N2	MBA Block Backside Gate	03.04.2021	58.8
N3	Backside Gate	03.04.2021	61.2
N4	Science Block	03.04.2021	64.8
N5	Biochemistry Block	03.04.2021	64.2
N6	Main Gate	03.04.2021	58.3
N7	IT Block	03.04.2021	53.9
N8	Commerce Block	03.04.2021	54.8
N9	Second Gate	03.04.2021	60.5
N10	MBA Block	03.04.2021	59.9
N11	Examination Branch	03.04.2021	56.9

Make of the Instrument: Lutron
Model & S.No: SL-4010

For B S Envi-Tech Pvt Ltd

Authorized Signatory

*Complaints Register is available at Laboratory.

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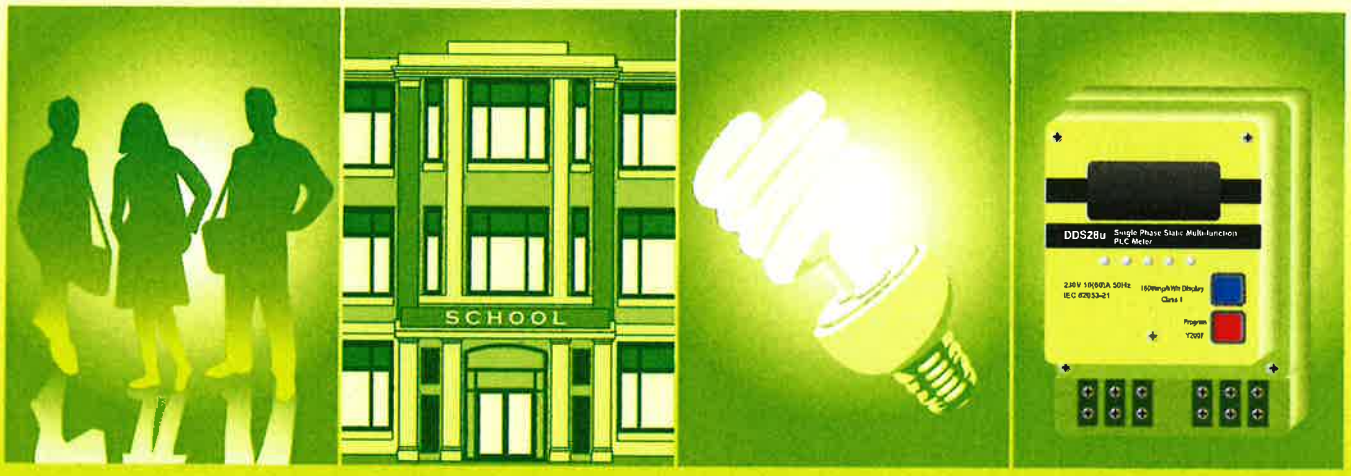
Energy Management
IN YOUR SCHOOL



ENERGY IS LIFE
BEE
CONSERVE IT
Bureau of Energy Efficiency

British High Commission
New Delhi

ICF
INTERNATIONAL

Energy Management

In your SCHOOL

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ENERGY IS LIFE ऊर्जा कार्यकुशलता ब्यूरो
(भारत सरकार, विद्युत मंत्रालय)
BUREAU OF ENERGY EFFICIENCY
CONSERVE IT (Government of India, Ministry of Power)

अजय माथुर, पीएच.डी
महानिदेशक
Ajay Mathur, Ph.D
Director General

FORWARD

The current electricity consumption in the commercial buildings sector in India is about 8% of the total electricity supplied by utilities. The electricity demand in commercial buildings is growing annually by 11-12% due to demands for providing international level comforts and facilities. This presents a challenge to ensure that energy growth in commercial building does not become unmanageable, but at the same time, also presents an opportunity to influence and address energy management issues in various commercial buildings and facilities.

Educational institutions are often overlooked as a contributor to energy intensive operations in India within the commercial buildings sector. Energy costs form one of the more manageable costs within a school's budget and can be managed effectively. Resultant cost and energy savings will go a long way in reducing energy use within the sector and provides a venue for re-investment within schools.

A review of international experience and several energy audit studies conducted in India indicate that schools can effectively reduce 5-20% of energy use. This "Guidebook for Managing Energy Use in Your School" developed by ICF International with the help of funding support from Strategic Programme Fund, Low Carbon High Growth Programme managed by the British High Commission in India, makes a concerted attempt to support the growing education industry in India in achieving improved energy performances. This guidebook aims to highlight several opportunities to create and implement an energy management plan within schools. Topics include the steps that are required to develop and implement an energy management plan, how to identify energy opportunities and how to evaluate costs and paybacks.

I am sure that the school administration and staff would find this document very useful, and that it would facilitate the process for achieving improved energy performances in school buildings.

(Ajay Mathur)
Director General
Bureau of Energy Efficiency, New Delhi

New Delhi, the 25th March, 2009

स्वहित एवं राष्ट्रहित में ऊर्जा बचाएँ Save Energy for Benefit of Self and Nation
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The Guidebook for Energy Management in Your School has been prepared by ICF International with financial support from Strategic Programme Fund, Low Carbon High Growth Programme of British High Commission in India. ICF International would like to acknowledge the contributions of:

Dr. Ajay Mathur, Director General, Bureau of Energy Efficiency for providing his guidance in developing this guidebook.

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Mr. Sanjay Seth, Energy Economist, Bureau of Energy Efficiency for providing technical inputs to the guidebook.

Mr. Anurag Mishra, Senior Program Officer, British High Commission for his valuable support in developing this guidebook.

Mr. Saba Kalam, Program Officer, British High Commission for his valuable support in developing this guidebook.

ICF International would also like to thank the schools in Bangalore, Hyderabad, Chennai, Delhi and NCR who provided the necessary energy use data to conduct an analysis to understand current energy consumption trends in different kind of school buildings.

Most importantly ICF International would like to express its sincere thanks to British High Commission, India for financial support, which made this guidebook possible.

Why Manage Energy Use

UNDERSTANDING THE INDIAN ENERGY CONTEXT

The Indian energy requirements are likely to grow at a much higher rate than the world growth rate of 2%. India has limited energy reserves and therefore it will need to increase its energy efficiency, in addition to reevaluating its existing building stock. Existing buildings offer one of the greatest potentials in contributing to energy conservation and if not evaluated also provide the greatest challenge of being energy hogs. This book highlights a methodology for implementing energy management in educational institution buildings.

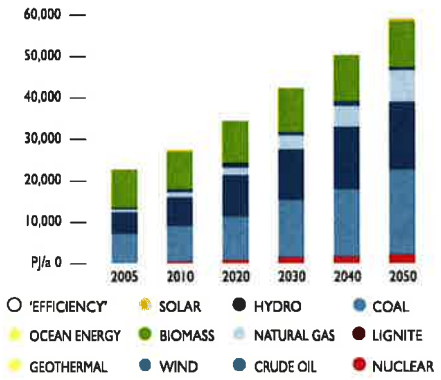


Figure 1 – Understanding the Indian Energy Consumption Scenario

ENERGY USE IN SCHOOLS

Schools are constantly faced with optimizing limited budgets to ensure maximum payback for students, teachers and their facilities. Rising energy costs associated with additional expenditure for replacing equipment adds strain to an already compact budget.

Energy maintenance is often overlooked in school buildings as the associated costs are relatively lower compared to other expenses. Schools can effectively reduce energy use, garner energy savings, and extend equipment lifetime through effectively implementing an energy management program.

Implementing an energy management program can save anywhere between 5-20% on energy bills. This will help improve your bottom line and holds down operating costs. An operations and maintenance based program can be relatively low in cost and still yield effective payback.

Managing Energy Use In Your Hospitals

- Initiate an Energy Management Program
- Determine Efficiency Targets
- Conduct Energy Assessments
- Identify Energy Savings Opportunities
- Calculating Costs and Paybacks
- Implement Measures
- Monitor Performance

Controlling costs is a key to profitability allowing your school to route resultant savings toward fulfilling other requirements including purchasing additional amenities, staff salary increases, etc.

IMPROVED LEARNING ENVIRONMENT

In addition to optimizing energy and saving costs, schools offer a critical platform for creating a better environment that includes favorable light, sound, and temperature, which can help students learn better. In many cases, improving these attributes can also reduce energy use. A research captured in Greening America's Schools: Costs and Benefits, highlights 17 studies that demonstrate productivity increases of 2% to more than 25% from improved indoor air quality, acoustically designed indoor environments, and high-performance lighting systems. Some of these studies show that day lighting, which uses the sun to produce high-quality, glare-free lighting, can improve academic performance by as much as 20%. Quality lighting systems include a combination of day lighting and energy-efficient electric lighting systems. These complement each other by reducing visual strain and providing better lighting quality. Advanced, energy-efficient heating and cooling systems create cleaner, healthier indoor environments that lower student and staff absentee rates and improve teacher retention. This translates into higher test scores and lower staff costs. For example, Ash Creek Intermediate School in Oregon has reduced absenteeism

(compared to the previous facility) by 15%. Lower construction and operating costs also signify responsible stewardship of public funds. This translates into greater community support for school construction financing. Schools that incorporate energy efficiency and renewable energy technologies make a strong statement about the importance of protecting the environment. They also provide hands-on opportunities for students and visitors to learn about these technologies and about the importance of energy conservation.

HOW TO MANAGE ENERGY USE

Energy management helps improve your bottom line and holds down operating costs. Energy costs typically represent a high proportion of a school's variable or "manageable" costs and expenses. On average, energy costs represent 16% of a school's "controllable" costs. As a result, in this era of tight budgeting, energy cost management has the potential of becoming a major source of flexible expenditure. (Adapted from "Schools and Energy Efficiency – Reducing Costs and Creating Better Learning Environments")

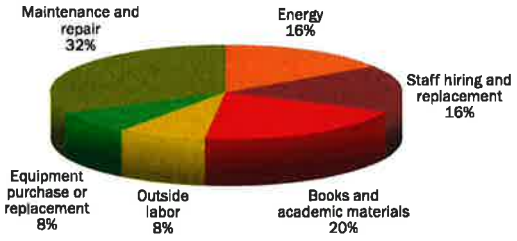
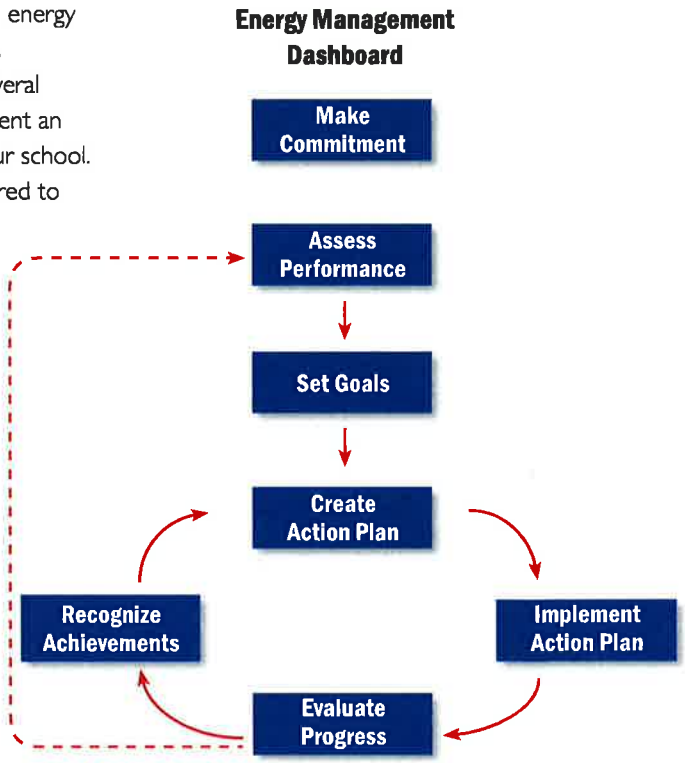


Figure 2 – Controlling Costs – A Typical US Example
Source: "Schools and Energy Efficiency – Reducing Costs and Creating Better Learning Environments"

There are numerous ways by which energy can be managed within your school. This guidebook aims to highlight several opportunities to create and implement an energy management plan within your school. Topics include what steps are required to develop and implement a management plan, how to identify energy opportunities and how to evaluate costs and paybacks.



Initiating An Energy Management Programme

"Good school buildings contribute to good education just as bad school buildings interfere with it.

Studies demonstrate the relationship between school infrastructure and student achievement, but this relationship is not straightforward, and a myriad of other variables go into making good schools. In other words, school infrastructure contributes to but does not decide the quality of a school. As such, infrastructure is not distinct from other issues of school reform or educational excellence; rather, school infrastructure decisions are a central component of whole-school reform." (Source: Planning Guide for Maintaining School Facilities, National Forum on Education Statistics and Association of School Business Officials International, p.14, February 2003.)

Before any energy management program can be developed a dedicated staff team is required to ensure that accurate objectives are set and the right people will implement the plan. In schools, a dedicated O&M team is generally not an integral part of the organizational structure; therefore it will be an important first step to identify who could play this role. This could be a roster based effort.

Understand existing energy use situation.
The first step in implementing an energy management program is to understand the existing energy use scenario within the school facilities. Details on deriving an energy baseline and determining efficiency levels within your school facilities are elucidated in the next chapter – "Determining Efficiency Targets".

Headteacher

School energy manager

Caretaking staff

Energy monitors

Identify a core team. The next step in initiating an energy management team is establishing a team of staff members who will play an integral role in the program. Identifying key staff members who will be involved in energy management activities and those responsible for overseeing the program is imperative for success. An effective team should include the school owner or members from the management group, the staff in charge of school facilities, several teachers to raise awareness among the student body on importance of energy management, and someone who understands finance. The school can also choose to include select students to raise morale and motivate students to "do their part" in efficient energy use. Commitment from the school administration and/or management and their involvement is vital to providing focus to energy management operations. Their attitude toward energy savings sets the pace for increased efficiency. Also, designate a mid level or upper level employee as "Energy Manager" to monitor energy saving activities and projects daily.

Once the team is selected organize an introductory session to start laying the groundwork for the program.

Identify and set specific objectives. Identifying the program goals and objectives helps establish a standard of comparison for success and also lays the path toward achieving desired results. For example, if you want to save 25% over the next 1-3 years you should consider the following –

- Have you defined the 25% as reduced consumption of energy or as reduced cost?
- What is the base you will measure against?
- How and when will the measurement be made?

Receive input from your team and plan workable goals and objectives to establish a baseline for your efforts. Use this phase to also identify related budget factors to achieve goals.

Develop a plan. Create an action plan to define the implementation of the pre-determined energy management goals and objectives. This plan will outline steps toward achieving desired results, delegate responsibilities, identify budget limitations and set targets for energy saving opportunities.

Communicate plan. Once the plan is established the success of the energy management program depends on the effectiveness of communicating it to the involved staff members and other individuals including students, parents, etc. Use the plan to delegate responsibilities to key staff from facilities and other involved staff members. Ensure that it is easy to understand and everyone shares the common goals and objectives of the program. Regular updates on program and visual tools to share progress are effective ways of building momentum within staff members.

Important Questions to Consider While Creating an Operations and Maintenance (O&M) Plan

- What tools and information do staffs currently have to effectively manage energy costs?
- What is the current status of O&M practices in my school?
- Would changes in facility O&M practices likely produce significant operating savings?
- Would senior administrators actively support an O&M effort?
- What local resources may be available to assist?
- Monitor Performance

Implement measures and monitor performance. Implementing identified measures and their monitoring with respect to associated results is imperative for the program. Without regular monitoring of program it will be difficult to evaluate any savings. Follow up is also required to ensure that measures have been implemented properly.

Motivate staff members. The key to keeping stakeholders onboard with your energy management plan is having a reward and celebrating successes. Don't wait until the end of a two year program to announce results. Have regular milestones and incentives to meet them. Make people feel part of the program's success and it will take on a life of its own. Create an environment where people work together to get things done and enjoy the rewards of achieving success on a regular basis.

Determining Efficiency Targets

According to the United States Environmental Protection Agency's ENERGY STAR program, the least efficient schools use three times more energy than the best energy performers. Energy costs are influenced by numerous variables that need to be taken into consideration while determining efficiency targets.

Before determining targets, a successful O&M program must clearly address the organizational issues likely to be encountered. An essential element of designing and implementing a successful O&M effort is anticipating and planning for the pitfalls likely to occur. Many of the barriers are a variation of two major themes; 1) the limited internal availability and distribution of complete, accurate and timely information with respect to energy cost, facility performance and staff maintenance and operational practices; and 2) the lack of clear leadership in energy management objectives and an associated under-investment in the staff resources and training necessary for effectively managing facility operating costs and reducing life cycle costs of school buildings. (Adapted from School Operations and Maintenance: Best Practices for Controlling Energy Costs)

Once these are recorded, the next step is to understand the factors that relate directly to the bottom line of energy costs - operating expenses, annual revenue etc. Operating expenses is one of the significant "constant" variables to be considered while determining savings objectives. Others like occupancy rate, cost of materials and supplies, will fluctuate based on external factors.

Operating expenses are largely influenced by actions you can take and on average, the cost of energy accounts for 3% to 5% of the total operating expense. Figure 3 below highlights select variables that will determine your efficiency targets.

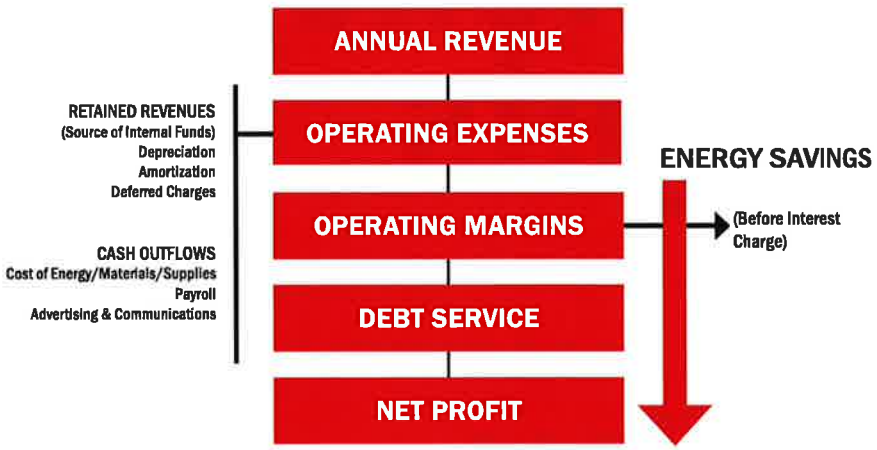


Figure 3 – Factors involved in establishing profitability for a school
Source: "Managing Energy in Your Hotel"

Where Is Energy Being Used

While studying the factors affecting energy costs within school facilities a key step is studying where energy is being utilized within your school. Identifying areas of high and low energy use will help you target key areas for improvement and also areas that will provide maximum returns. Figure 4 below highlights K–12 energy consumption by end use in the U.S based on data from the U.S. Energy Information Administration.

Similar graphs can be constructed for your school by analyzing your energy bills. Understanding the school's energy use will help you establish a baseline from which you can determine a suitable and more importantly an achievable efficiency target that can be reached through implementation of energy management best practices.

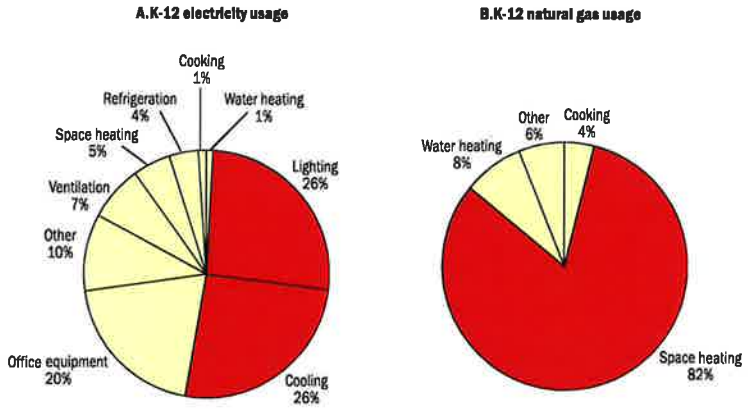


Figure 4 –K–12 energy consumption by end use in the U.S.
Source - Managing Energy Costs in Schools (http://www.esource.com/BEA/demo/PDF/CEA_schools.pdf)

Conducting Energy Assessments

An energy assessment is an essential component of a successful energy management program. This will help you identify the present energy use situation within the school facilities and flag energy costs. Energy saving opportunities can be identified based on the assessment report. The assessment will also help you develop a baseline for future comparisons of program success by comparing energy use before program implementation and after.

Schools can conduct either a basic **walk-through energy assessment** or a more detailed **energy analysis audit.** Schools also have the option of carrying out the assessment as a first step to identify existing energy saving opportunities and implement the results followed by a more detailed analysis audit to derive more detailed measures for savings including capital intensive energy saving opportunities.

This guide focuses on the walk-through energy assessment process as a means for schools to delve immediately into saving energy and improving their bottom line through less capital intensive measures. Schools are encouraged if they desire to follow the implementation of these measures with a more detailed audit to garner additional savings.

Performing A Walk-Through Assessment

Often 25% of a commercial building's energy consumption is wasted due to specific management practices. Simple adjustments to management and operation practices can result in savings for your school. For example, adjusting the Building Automation Systems (BAS) to more effectively control your lighting can result in significant savings.

A walk-through assessment is the easiest and least expensive means of identifying and evaluating energy use in your school building providing you with a tangible sense of current building conditions and staff operations and maintenance practices. Since people have a major affect on how energy is used, this assessment pays particular attention to identifying habits and procedures that can be adopted to use energy more efficiently. Basic information about the systems in your school is also collected during this process.

The point of a walkthrough survey is NOT to take measurements or conduct technical equipment testing. The objective is to produce a quick snapshot of the highlights of how the building is being operated and maintained with respect to energy use. Although a variety of useful building survey protocols are available from consultants and government agencies, the primary information of importance is the following (adapted from "School Operations and Maintenance: Best Practices for Controlling Energy Costs")

- Building use and occupancy schedules;
- Shutdown procedures during unoccupied periods;
- Status of control strategies for major equipments and systems in the building;
- Classroom lighting levels and fixture control;
- Heating and cooling system efficiency and maintenance practices;

- Condition of water or air distribution systems;
- Temperature control and setbacks;
- Condition of building envelope, windows and weather-stripping;
- Identification of prominent problems (indoor air quality etc.);
- Control of computers, vending machines and other plug in loads;
- Assessment of staff expertise.

The first step in this assessment is to examine energy use and associated costs across systems within your school. Utilize your operations and maintenance staff to assist in this process. Provided in the following pages are –

1. Energy Planning Ledger – assist you with highlighting required information to initiate the assessment
2. Questionnaire for the Operations and Maintenance (O&M) Staff at specific school(s) energy policy and building
3. Walk-Through Assessment Checklist – assist you with identification of energy saving improvements that can be easily implemented.

Use all these sheets while walking through your school building and recording information on energy use. The sheets can be modified to suit existing systems in your school buildings.

Energy Planning Ledger

How much energy does your school use? Ask to see your school's energy bills for the previous year or two.

Acquire school electricity bills for a 12 month period and use them to fill out the ledger provided below If bills are paid on a monthly basis, combine bill amounts for three consecutive months to make up for a quarter of the year.

School Building Statistics

Carpet Area Sq. Ft. _____

Air conditioned Area Sq. Ft. _____

Number of Floors: _____

Building Age: _____

Energy Source

Electricity: _____ % of total cost

Gas: _____ % of total cost

Total electricity use per quarter _____

Total cost per quarter _____

Number of billing days _____

Number of students and teachers at your school _____

Billing periods (from-to)	No of Days	Electricity cost for each period * ($)	Electricity consumed / period* (KWh= kilowatt hour)
		(C)Total cost for year $	(D)Total energy usage for year_____KWh

** If gas is also used for energy in your school, the table provided above can be modified to include gas readings.*

With this information you can determine the past:

Daily Use of Energy
Total use per quarter / number of billing days (kWh/day) _____

Personal Daily Use of Energy
Daily use / size of school population (kWh/person/day) _____

Daily cost
Total cost per quarter / number of billing days ($/day) _____

Personal daily Cost
Daily cost / size of school population ($/person) _____

Hot Water Uses: _____

Predominant Type of Indoor Lighting: _____

Predominant Type of Outdoor Lighting: _____

School Operation Hours: _____

This ledger will help you ascertain an energy use baseline that will allow you to measure the success of your energy management program at regular intervals.

Questions For O&M Staff At Specific School(s) Energy Policy And Building

Questions for O&M Staff at Specific School(s) Energy Policy and Building

Operations Procedures

1. Is there any specific kind of standard building operating and maintenance procedure in your building?
2. What maintenance records do you keep? Of particular interest are the testing and maintenance of air-conditioners and other major building systems.
3. What was the date of your last assessment of energy use or other important actions related to energy conservation?

Building Energy Information

4. Are annual energy costs at your school increasing or decreasing? What are the reasons for these changes?
5. Are you provided with the monthly energy consumption or billing information for your school?
6. If yes, how do you use this information?
7. Do you know how energy costs at your school compare to costs in other similar schools?

School Condition and Operations

8. What are the major problems in respect to the condition of equipments and appliances in your school? (Poor maintenance, staffing etc.)

9. How are maintenance decisions made? How does the administration plan, track or schedule maintenance activities at individual schools, particularly for large systems such as air-conditioning systems?

10. Are you aware of any recommendations for changes in O&M practices that have been made in energy audits or other sources?

11. Do you have any recommendations for reducing energy costs at your school?

12. Does your school have a computerized energy management system (EMS)? Is it working effectively? Which building systems does it control? Does your staff know how to operate it effectively?

13. Can you briefly describe night time, vacation and weekend shutdown procedures currently in place in your school? Is there a written procedure available?

14. What are the current thermostat settings and night time temperature setbacks?

15. Are teachers, students and staff careful about turning off computers and other equipment when not in use?

O&M Staff Training

16. What training has been provided to your schools custodial or maintenance staff that is relevant to reducing energy costs in your school?

17. Can you identify any specific training needs that would enhance staff's ability to manage energy costs?

Walk Through Assessment Checklist

CHECK LIST	ACTION LIST	OBSERVA-TIONS
	HEATING & COOLING	
Window and Split ACs -		
	OPERATION ° Control operating hours of AC unit- use manual control, timers, automatic controls. ° Keep doors and windows closed when using the AC. ° Ensure that thermostat settings are not set too high or too low - aim for 24-25°C in winter and 22-23°C in summer. ° Locate AC on shady side of building away from direct sunlight where possible. ° Avoid frequent opening of doors/windows of the room.	
	MAINTENANCE ° Regularly replace or clean the filter and have a mechanic clean the evaporator and condenser coils ° Clean and replace thermostat regularly. ° If your compressor doesn't work properly, call a service person immediately. ° Any AC noise needs to be checked by a mechanic.	

Fans –		
	OPERATION ° General classrooms require 2-4 ceiling fans ° Ceiling fans should have a head clearance of 600–900 mm for safety ° Metal blades are the most effective ° Units should be mounted clear of existing light fittings to avoid annoying flicker	
	MAINTENANCE ° Turn off the fan when the room is not in use. ° Inspect the fan each year. ° Clean the fans every month or two. ° Dust the areas surrounding the ceiling fan.	
HVAC -		
Check temperature and humidity levels in various areas: - Class Rooms - Conference Rooms - Staff Rooms - Lab Areas - Auditoriums - Dining rooms - Corridors - Lobby	**OPERATION** ° Monitor outside air use ° Avoid heating and cooling at the same time ° Use modular, localized heating/cooling units where possible ° Control system by time-of-use when possible for public areas ° Use ceiling fans to increase comfort ° Shut off chiller during winter if possible.	

Check ductwork and airflow Check condition of windows and doors Check refrigerant levels.	**MAINTENANCE** ° Seal ductwork leaks ° Clean filters and allow free air-flow to grills ° Seal unused building openings ° Install vinyl curtains in loading areas ° Weather-strip doors and windows, caulk cracks ° Insulate: doors, pipes, ductwork ° Cover and lock thermostats and ventilation controls in public areas to prevent unauthorized adjustments ° Clean boilers, chillers and condenser coils regularly, straighten fans.	
Check thermostat readings Check availability of passive solar	**PROCEDURES** ° Do not heat/cool in low traffic areas, hallways or unoccupied rooms/floors ° Adjust building temperature by season: lower in winter / higher in summer ° Utilize available passive solar heat during cooler months by opening blinds and drapes ° Close doors to outside and unheated or un-cooled areas ° Use ventilation only when required ° Establish routine maintenance procedures ° Plan occupancy so guests are assigned in same area of school ° Have facilities staff close draperies and adjust thermostat to acceptable level in unoccupied area or rooms.	

LIGHTING		
Check when lights are being used. Check lighting levels.	**OPERATION** ° Use automated lighting Controls - Timers o Outside lighting o Playgrounds o Parking lots o Restricted-access areas - Motion sensors o Rest rooms o Principal & senior staff offices o Low-traffic areas - Dimmers o Auditoriums o Meeting rooms - De-energize fixtures/ballasts not in use - Reduce lighting to minimum acceptable level for safety/security o Parking areas o Canteen o Corridors	
Check cleanliness and condition of lamps and fixtures Check accessibility of switches	**MAINTENANCE** ° Clean lamps for maximum illumination ° Repair broken fixtures ° Replace non-working lamps/bulbs ° Install lowest acceptable wattage bulb ° Install energy-efficient ballasts ° Add reflectors to existing lighting ° Label panels and switches so lighting can be monitored and controls can be accessed	
Check how lights are being used	**PROCEDURES** ° Turn off lights not being used ° Use task lighting in place of area lighting where possible	

Importance Of Data Collection & Use

The data must be complete and accurate because it will be used for analysis and goal setting. Consider the following when collecting energy use data:

- Determine appropriate level of detail — the level and scope of data collection will vary from school to school. Some may choose to collect data from sub meters on individual processes while others may only look at a utility bill.
- Account for all energy sources — inventory all energy purchased and generated on-site (electricity, gas, steam, waste fuels) in physical units (kWh, mMBtu, Mcf, lbs of steam, etc.) and on a cost basis.
- Document all energy uses — for the sources identified above, assemble energy bills, meter readings, and other use data.

Energy data may reside in the accounting department, be held centrally or at each facility, or can be acquired by contacting the appropriate utilities or energy service providers. Gather at least two years of monthly data or a more frequent interval if available. Use the most recent data available.

" Figure 5- Students Making Presentations on School Energy Use
Source – "School Energy Audit"

Collect facility and operational data — To be able to normalize and benchmark, it may be necessary to collect non-energy related data for all facilities and operations, such as building size, operating hours, etc.

Another important factor to consider is the use of energy data collected and the awareness generated on the associated operations and maintenance programs. It is vital that the school administrations, staff and students are educated on both the programs and the data collected.

Schools have effectively used outreach strategies including periodic program newsletters, school board presentations, and websites. Data collected can also be displayed in posters across the school buildings in staff rooms, corridors, libraries and labs. Regular updates through short presentations on energy use to staff and students during morning assembly are also an effective tool. Examples of outreach strategies are highlighted in figure 5 above and figure 6 below.

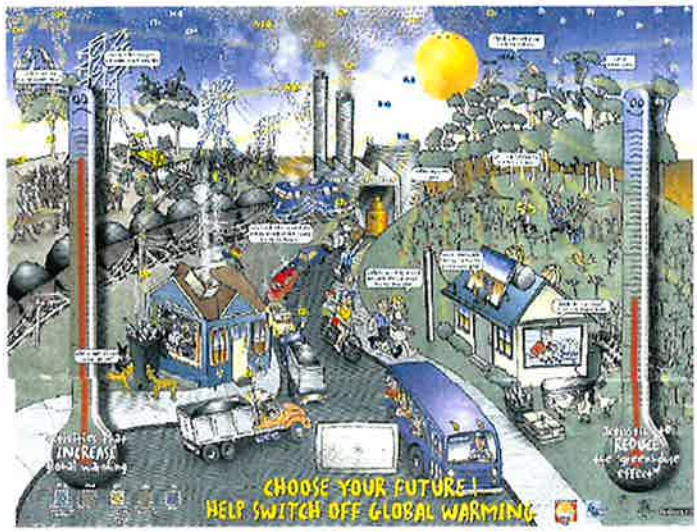


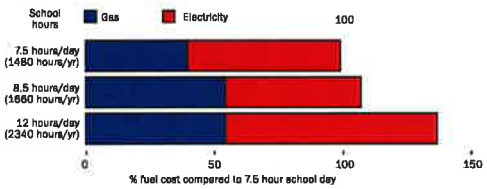
Figure 6 - Example of Poster on Energy Use
Source – "School Energy Audit" - Wetlands Environmental Education Centre
Compiled from resources developed by Observatory Hill EEC

An operations and maintenance program devoid of visibility and effective use of data collected will affect support levels from staff, students and the administration. Regular data use will also ensure that the energy use practices carried out match the mission goals outlined at the offset of the program.

Identifying Energy Saving Opportunities

Identifying Energy saving opportunities is a key step of an energy management program, the opportunities should be identified in the following steps, the first and foremost focus should be to address all maintenance issues, the next is to focus on exploring appropriate changes in the operations, third should be to look at system improvements, part and whole and the fourth and the last focus should be to evaluate replacement options. This flow of evaluation also aligns with the low and no-cost measures first and then looks at capital investment.

Energy management in school facilities varies from other regular commercial buildings due to factors like funding, operation hours, limited infrastructure, etc. For example figure 7 below indicates the effect of extended school operation hours on fuel costs.



" Figure 7 - The effect of extended hours on fuel costs
Source – "Energy Savings in Schools

Schools should look at their individual systems based on the type of facilities they manage and the services they offer to identify areas for maximum savings.

A UK guidebook on schools suggests the following generic distribution of energy costs across systems –

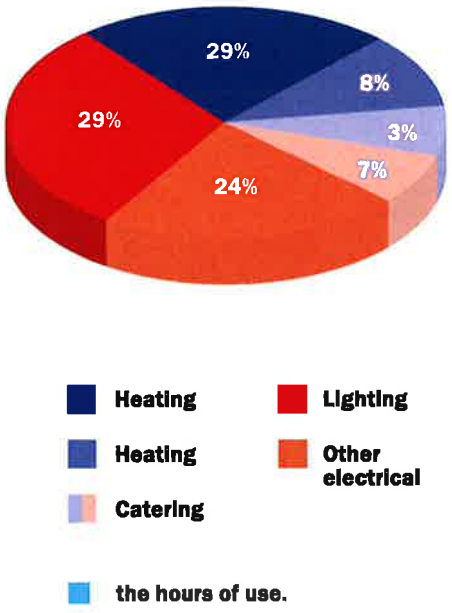


Figure 8- Typical distribution of energy costs : blue tints – fossil fuels, red tints – electricity (1992 figures adjusted to reflect 1997 figures
Source – "Energy Savings in Schools"

Figure 8 above indicates the higher potential for savings in areas like lighting and heating due to the associated higher costs.

Lighting

The lighting system is the most visible energy user in the building accounting for nearly 50% of the electric bill at times. Savings from lighting efficiency are some of the most rewarding to achieve because most are easy to make and cost little or nothing.

Identifying Savings Opportunities within your Lighting Systems

The main lighting systems at a school consist of classroom and office lighting, external security lighting, gym lighting, and, exit and emergency lighting. Begin your lighting improvement project by determining how much light is really needed in the various areas of the school and its surroundings. Areas where people are walking as opposed to seated or working require very different lighting levels, but all too often are lit to the same high levels.

Do a walk-through of the facility looking at the existing lighting in each area and the area's lighting needs. It's a good idea to use a light meter (lighting suppliers often lend them). You can then compare your present lighting levels to recommended levels for the tasks being performed.

RECOMMENDED LIGHTING LEVELS FOR SCHOOLS

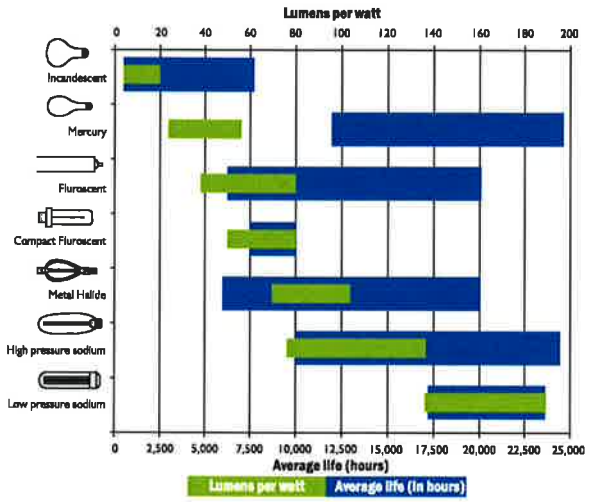
AREA	FOOTCANDLES	TYPE OF LIGHTING
Classrooms-general	50-75	Fluorescent
Classrooms-art	50-75	Fluorescent
Classrooms-computer	50-75	Fluorescent (indirect)
Classrooms-drafting	75-100	Fluorescent
Classrooms-sewing 7	5-100	Fluorescent (task lighting)
Labs-general	50-75	Fluorescent
Labs-demonstrations	100-150	Fluorescent (task lighting)
Auditorium seating areas	10-15	Fluorescent
Auditorium concerts on stage	50-75	Fluorescent
Kitchens	50-75	Fluorescent
Cashiers	20-30	Fluorescent (task lighting)
Dishwashing areas	20-30	Fluorescent
Dining areas	10-20	Fluorescent
Corridors & stairwells-elem	10-15	Fluorescent
Corridors & stairwells-middle	20-30	Fluorescent
Corridors & stairwells-high	20-30	Fluorescent
Gymnasiums	20-30	Metal Halide/Fluorescent
Media centers	50-75	Fluorescent
Offices	75-100	Fluorescent
Teacher workrooms	30-50	Fluorescent
Conference rooms	30-50	Fluorescent
Washrooms	20-30	Fluorescent
Building exteriors/parking lots	1-2	Sodium/Metal Halide

As you walk through the school building, also note the type of lighting present. One of the keys to improved lighting efficiency is using the most efficient light source to produce light. Incandescent bulbs are least efficient and have the shortest lives, but have the advantage of low first cost, good color rendition and easy installation. Fluorescents are popular in general because they are 4 to 5 times more efficient and have 10 times the life expectancy of incandescent.

High Intensity Discharge (HID) lamps, which were once used almost exclusively outdoors because of their poor color rendition, are more and more being brought indoors in color-corrected versions due to their extremely high efficiency and long life.

First, Do Things That are Free

- Remove unnecessary lamps. Because a number of schools were designed and built in an era when energy efficiency was not a high priority, lighting levels often are higher than necessary. But be careful. If you remove lamps near windows, make sure there will still be enough light on overcast days or at night.
- Make sure lights are turned off when an area is unoccupied. For the most part in schools, that means getting staff and students on-board with the program.
- Use switch plate covers reminding people to turn lights off when leaving an area. In public places, staff and students



are hesitant to turn lights off without "permission," so signage is important. Wind-up timers, time clocks and occupancy sensors can help get lights off when they are not needed.

- Keep the fixtures clean to be sure you are getting all the light for which you are paying. Cleaning fixtures and reflectors can compensate for reduced light levels from de-lamping.

- Consider group re-lamping, which means changing all the lamps at once rather than as they burn out. Light output from lamps decreases as they age, so replacing them in a group assures you get full light output, and the practice can reduce the maintenance costs associated with lamp replacement by half.

Low -Cost and Low - Investment Projects

After doing the no-cost projects, consider modifying the lighting system. Many projects require only a small investment. Before investing, calculate the payback period and, for large expense projects, consider life cycle costs to see if the project will be a good investment. And, try an improvement in a small area before committing to major changes.

A. Retrofitting signs is one of the quickest payback projects in many schools. The idea of replacing conventional signs with energy-efficient compact fluorescent ones has been widely promoted over the past ten years. Instead of incandescent light bulbs that last a few months, compact fluorescent exit signs require only about 12 watts and generally last two years in continuous use.

Converting to LED signs has become more popular. The light emitting diode, or LED meets electrical code requirements in most applications, uses minimal amounts of electricity and lasts up to 50 years. LED's are winners for cost savings and avoiding the inconvenience of replacing lamps.

S. N.	Cost Description	LED Lights	Incandescent Bulbs
1.	Lifespan	60,000 Hr.	800 Hr.
2.	Number of bulbs used in 60,000 hours	1	75
3.	Cost	INR 1000.0	INR 10.0
4.	Power dissipation	4 Watt	20 Watt
5.	Power savings per year*	140.0 kWh	-
6.	Lifetime power savings	960.0 kWh	-
7.	Cost saving per year	INR 490.0	-
8.	Lifetime cost saving	INR 3360.0	-
7.	Payback period	2-years	-

** With one bulb in use for 24 hours and 365 days in a year. The power cost is INR 3.50/kWh.*

B. Retrofitting Corridor Fixtures if applicable are also a quick payback project in schools. Attractive fixtures that house compact fluorescent lamps with color rendition similar to that of an incandescent are available. In most cases, no one will notice the difference.

C. Installation of more Efficient Lamps is one of the most effective ways to make lighting more energy efficient. Here are some of the best examples:

Replace Incandescent Lights with Compact Fluorescents

The standard incandescent light bulb may seem inexpensive, but it is not a bargain. Not only is it extremely inefficient, less than 10%, it also has a very short life, which means it must be replaced frequently. One of the great advances in lighting technology is the compact fluorescent lamp. Developed as a replacement for the common incandescent light bulb, the super energy efficient compact fluorescent is a spiral or miniature U-shaped fluorescent tube and ballast. Screw-in or pin holder compact fluorescents fit many of the fixtures where you previously used incandescent light bulbs.

This makes it possible to replace an incandescent (15 lumens/watt, 800 hours life) with a more efficient and long lasting fluorescent lamp (70 lumens/watt, 6000 hours life).

Consider that you can replace a 60-watt incandescent with a 15 watt compact fluorescent that will last 10 times as long and will deliver about the same amount of light for one quarter the energy. Compact fluorescents are more expensive than incandescent, but they will more than pay for themselves with savings in electricity, lamp replacement and labor costs. Payback is quickest when they are installed in fixtures that are used for many hours each day.

Compact fluorescents are available in a wide variety of styles to suit most lighting needs, with reflectors and extenders that can make them fit and work well in many fixture types. They come either as one-piece screwing units that include the ballast or as modular units where the tube can be separated from the ballast when the lamp burns out. The compact fluorescent tubes have lifetimes of 10,000 hours, while the ballasts last 4 or 5 times that long.

Compact fluorescents can be used outdoors when they are protected by an enclosure. However, they have some cold limitations. For instance, they are dimmer for a short time when they start, until they get up to their operating temperature and may not start at all when it is very cold. Using an enclosed light fixture helps. Ask your supplier which would be the best option for your outside needs.

Fluorescent Ceiling Lights

Since some lighting systems in schools are fluorescent, let's look at what can be done to improve their efficiency. There are four primary options –

1) Install lower wattage or more efficient lamps - When selecting new, more efficient fluorescent lamps, make sure they are compatible with the existing ballasts, although it may be cost-effective to replace the ballast as well. While some of the replacement lamps may yield slightly less light, this may be acceptable since in many areas you may have more light than you need. Furthermore, when clean new lamps are installed, and the diffuser and reflecting surfaces of the fixture are cleaned, there may be an increase in light output even with lower wattage.

2) Replace the ballasts - Replacing existing magnetic ballasts is often one of the most cost effective energy improvements. For instance, installing an electronic ballast can reduce the energy consumption of a fixture with two 34-watt lamps from about 74 watts to about 59 watts, a 20% drop, with no reduction in light output.

3) Replace the fixtures - Fixture retrofits can involve changing out the ballast, replacing yellowed or hazy lenses, diffusers, and globes with new ones that will remain brighter and transmit more light, and installing reflectors that "bounce" more light out of the fixtures. New lenses and reflectors may enable you to use fewer or lower wattage lamps and still achieve acceptable lighting levels.

4) Rewiring or installing more efficient controls can be an effective investment, with a fast return.

D. Educate and Motivate Staff and Students. Invariably, there are lights, computers, and other electronic equipment left on by staff and students who forget to shut down their workspace. Both security and cleaning staff in addition to teachers and students can play an integral role in energy management by assisting in overall savings.

Form a student energy patrol to ensure lights are out when rooms are empty (check classrooms, the cafeteria, the auditorium, etc.). Encourage all staff members to turn off lights through signage and other modes of communication.

E. Some Other Tips

Control Outdoor Lighting. Some schools have lights that are left on all the time for code compliance or to meet safety and security needs. While meeting code requirements, use only lighting necessary to do the job. It is recommended that the outside lighting should also be fitted with timers. Different timing should be set for summer and winter months. The alternative lights can be switched off after 11.30 pm. It is also recommended to create zones of every third lamp, and have each zone turn on 30 minutes apart, and turn off 30 minutes apart, instead of all at once.

Rewiring. If your present switches don't give you enough control to turn off unneeded lights, you should consider rewiring and installing additional switches or dimmers.

Occupancy sensors. In public areas where staff and students forget to turn lights off, an occupancy sensor may be the answer. These easy-to-install motion detecting devices turn lights on and off automatically in a space such as a restroom, storage area or stockroom. A sensor can be mounted on the wall where a light switch would normally go or can be installed in the ceiling or high on a wall. Occupancy sensors are activated when they detect motion, heat or both. Energy savings from sensors is greater the more hours the lights are off and the more watts controlled by the sensor. Savings from 20% to 40% are possible and even greater savings are possible when spaces are infrequently used. Consider installing occupancy sensors in the following:

staff rooms, conference rooms, student locker rooms, restrooms, stockrooms, and storage areas. While providing the sensors in toilets it is important to note that WC areas should be kept out of the circuit to avoid inconvenience to the guests.

Use Task Lighting. Install desk lamps for close work at office desks and staff room desks. This type of task lighting puts light where it is needed, when it is needed, and may permit ceiling lighting levels to be lowered.

Use Day lighting. Day lighting is the practice of using free light from the sun during the day to supplement or even eliminate purchased light. Taking advantage of day lighting may require installation of blinds or shades to control heat gain and glare. Combining this with rewiring and installation of switches will enable you to save money by turning off lights when they are not needed.

Cooling

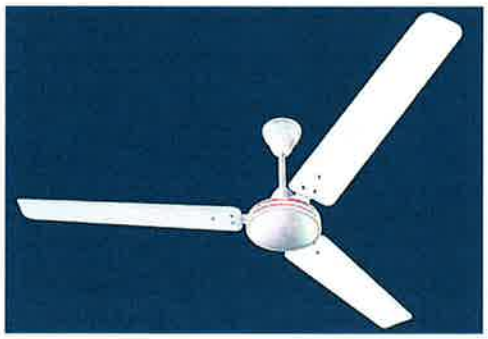
Save on energy costs without sacrificing comfort. It's expensive to heat and cool school buildings, but indoor temperatures must be comfortable so teachers can concentrate on teaching and kids can concentrate on learning. Using fans can make people feel degrees cooler, at much less cost than air conditioning. (Adapted from the Alliance to Save Energy tips for schools)

Schools in India primarily use fans, split air conditioners (ACs), and/or window units to cool their buildings.

USING FANS

Fans produce a cooling effect by moving air over the skin. Although they do not reduce actual room temperatures or humidity levels, fans can often provide an adequate level of comfort and provide the cheapest method of cooling. In winter (if applicable), ceiling fans redistribute the warm air that collects near the ceiling to the lower part of the space for comfort.

Use the "Fans" checklists provided in this guidebook (can be found in the section "Conducting Energy Assessments") during your walk-through of the facility to garner tips on efficient use of the system.

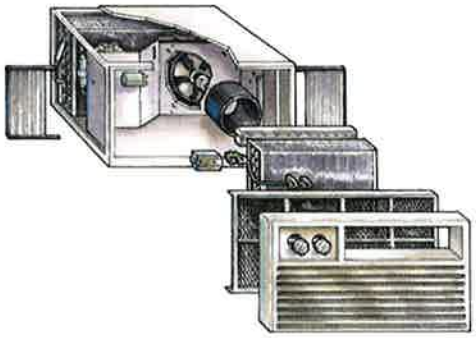


Ceiling Fan

USING WINDOW UNITS AND/OR SPLIT AIR CONDITIONERS (ACs)

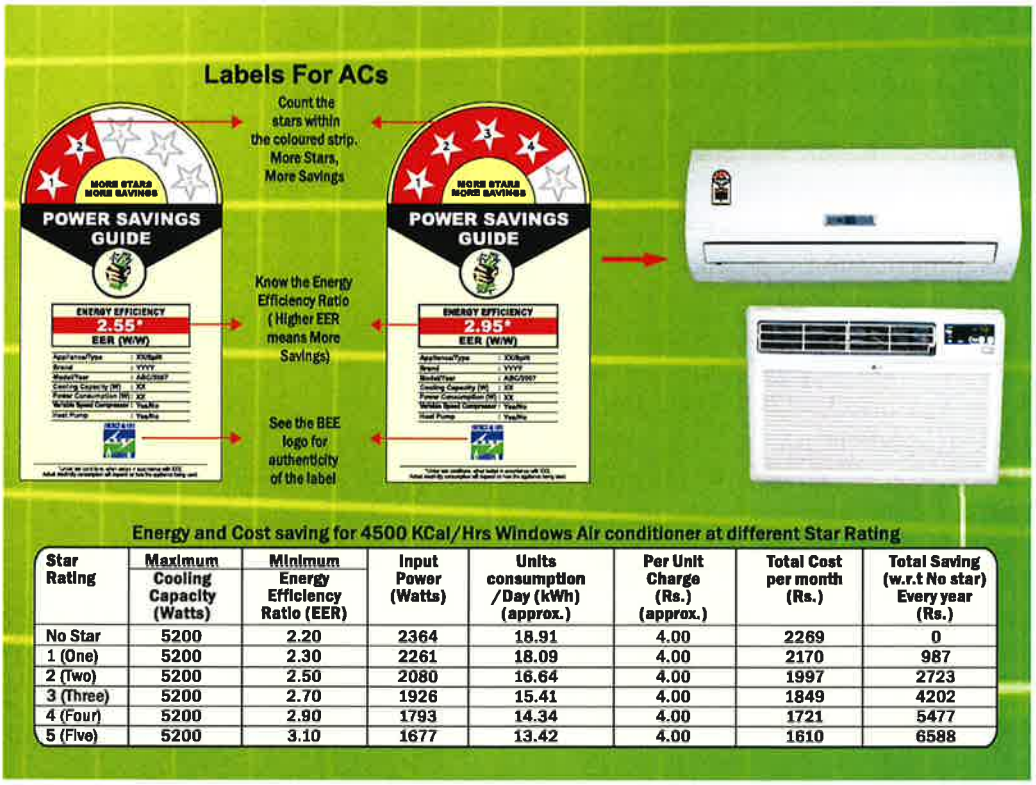
Window units and split ACs comprise options provided under the realm of domestic refrigerative air conditioners. Here the compressor is located separately to a cooling head that is usually mounted on a wall or ceiling inside the building. The compressor can be in a less obtrusive outside location, provides for quieter operation and is connected to the cooling head by insulated pipes.

Refrigerative air conditioners are sized in kW according to the rate at which they can transfer heat. This rating of an air conditioner's cooling ability is usually 2 to 2.5 times the electrical power required for their operation. The correct size of an air conditioning system depends on many factors including: building construction, level of insulation, shading of windows, room size, number of people in the room and their activity and the presence of other heat generating sources such as computers and lights. A north-facing General Purpose Classroom measuring 7.2 m x 7.2 m with 25 students and three computers would require about 9 kW of cooling. It should be noted however that the largest domestic type air conditioner available is rated at about 7.5 kW. (Adapted from "Guide to School Cooling – Resources for School Energy Managers")



Window AC

When buying an air-conditioner (window or split unit), always buy BEE labeled air conditioners having rating between 3 to 5 stars. Use the table given in the picture in the following page to choose the AC unit for your school.



Energy and Cost saving for 4500 KCal/Hrs Windows Air conditioner at different Star Rating

Star Rating	Maximum Cooling Capacity (Watts)	Minimum Energy Efficiency Ratio (EER)	Input Power (Watts)	Units consumption /Day (kWh) (approx.)	Per Unit Charge (Rs.) (approx.)	Total Cost per month (Rs.)	Total Saving (w.r.t No star) Every year (Rs.)
No Star	5200	2.20	2364	18.91	4.00	2269	0
1 (One)	5200	2.30	2261	18.09	4.00	2170	987
2 (Two)	5200	2.50	2080	16.64	4.00	1997	2723
3 (Three)	5200	2.70	1926	15.41	4.00	1849	4202
4 (Four)	5200	2.90	1793	14.34	4.00	1721	5477
5 (Five)	5200	3.10	1677	13.42	4.00	1610	6588

A. Keep System Off During Unoccupied Times. The best time to save money in an area of the school is when no one is there. All too often energy is being wasted heating or cooling the air when nobody is there. Making matters more complicated, your occupancy hours are different for the various parts of the school building, like when there is a program in the auditorium. Temperature can only be controlled for individual areas when there are separate heating or cooling units, zones, or thermostats.

B. Replace/Clean Filters & Coils. It's one of the simplest of the conservation measures, and it's often overlooked. Take time to check that there are filters in place and see that coils and filters are cleaned and changed regularly. Filters and coils are the two most critical elements in any cooling system depending on whether they utilize window units, split air conditioners and/or HVAC systems. They are where the mechanical system interacts most directly with the environment it is trying to impact. It does not take much dirt and dust to degrade thermal transfer across the coils, and as filters get dirtier, air delivery to spaces and fan energy required to deliver air will suffer. Very aggressive cleaning schedules for coils and filters are always a part of the maintenance regime for buildings. It is very common to observe dirty filters and coils even when maintenance staff reports an aggressive approach. Often, teams will rely on pressure drop alarms in the BAS system to signal the need for filter cleaning. Our experience in the field indicates that this is not a proactive approach associated with capturing available low-cost savings.

Ensure that the school has regular maintenance schedules for their cooling systems and for cleaning of coils and filters. It is recommended that the coils and filters be cleaned very aggressively and on schedule (preferably every month). Close inspection of coils and filters on a periodic basis will be the best initial indication as more aggressive schedules are set. The amount of dirt on the coils and filters

Examples of Filters

can easily be determined by wiping the surface with a finger or clean cloth. As this measure is less popular with maintenance staff, motivation and oversight are required, which might result in a checklist that appoints a responsible staff person to ensure on time completion. Replaceable filters can be cleaned in batches to reduce labor associated with this measure, and pre-filters can be considered depending on local condition. Where coils and filters are difficult to access, it is important to document the process, appoint specific staff who can learn to do the job efficiently, and evolve cleaning techniques that are appropriate to the challenge. For example, if coils and filters are in terminal units above high end conference space, frequent cleaning with a liquid chemical solution may not be feasible compared to brushing, vacuuming, and forcing compressed air through the coils. The goal is to look at

current conditions and practices and come up with a reasonable definition of an aggressive, sustainable approach.

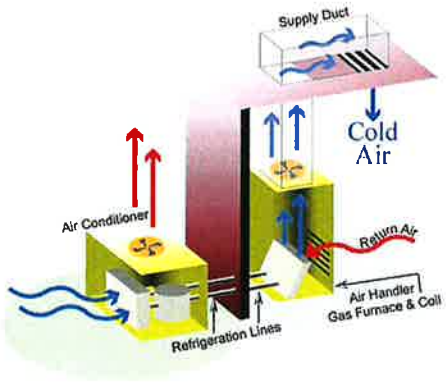
The estimated savings for this measure are difficult to calculate but with past experience it has been observed that this practice can save between 10-20 % of electricity use every year as very clean coils and filters are a fundamental part of excellent HVAC performance and should not be treated as an option to be weighed against others.

C. Adjust Temperature Set Points in the Units. Different sections of the school building have different expectations for interior temperatures associated with seasonal climatic temperature conditions. About 1°C reduction in interior temperature settings during the winter months (October to February) can save as much as 5% in energy costs during these months. By carefully selecting seasonal set points that meet but do not exceed comfort expectations, considerable energy can be saved and guest satisfaction can be maximized.

D. Plan Ahead. People rarely plan for an equipment failure, and when one occurs you will be under pressure to get it up and running right away. This makes it difficult to shop and plan for energy efficient replacements. So, prepare in advance for likely units that may fail, particularly in student areas, and check on the price and availability of efficient units. HVAC systems last a long time, so your school will live with the replacement for many years to come.

Using an HVAC System

Select schools in India have an HVAC system in place for cooling. Depending on usage finding savings of 20% or higher are quite often possible through more efficient operation and maintenance of the HVAC system. Much of the savings will come from simple things you can do yourself like keeping the system off when it is not needed, or operating it less by changing temperature settings. The remainder of the potential savings comes from making the system more efficient.



Use the HVAC checklists provided in this guidebook (can be found in the section "Conducting Energy Assessments") during your walk-through of the facility to garner tips on efficient use of the system. These include –

A. Put Locking Covers on Thermostats if Applicable. Determine a reasonable setting and cover programmed thermostats in public areas with tamper-proof covers or look into replacing them altogether with ones that hold a fixed setting. Make sure to also check the accuracy of thermostats. At a time when your heating or cooling system has the school at a stable temperature, walk through with an accurate thermometer and see if the thermostats are accurately recording the temperature. If the thermostat says it is 21°C and the actual temperature in the space is 23°C, the heating system may be running more than necessary.

B. Inspect and Repair Duct Leaks. In air distribution systems, take a look at the duct system as part of your energy check-up. Over the years, these systems deteriorate and can even get stepped on and damaged by contractors and technicians working in the area. Fix broken joints and other leaks, and be sure they are insulated if they run through unconditioned space.

There are plenty of ways to get your students involved to assist with this –

- Have students determine areas of energy loss by using "draft meters" made from plastic wrap and pencils to study where drafts are coming in.
- Avoid infiltration in conditioned spaces - Have students help replace insulation and stuff energy loss "holes" through innovative measures, such as making translucent window quilts to hang in classrooms and "insulation snakes" to put at the bottom of doors and windows.
- Work with facility staff to install permanent weather stripping, caulking, and insulation.

Building Envelope

Careful consideration should be given to the use of natural and passive methods of cooling. It is more efficient and effective to stop heat entering a building rather than having to remove heat to lower internal temperatures.

While it consumes no energy itself, the school building envelope has a large influence on a major energy consumer, the air-conditioning system. The envelope consists of the buildings outside walls, its roof, windows, doors, and floors. It is the barrier or filter between the inside conditioned space and the outdoors.

When it operates effectively, your buildings will require less energy. From an energy perspective, its purpose is to minimize heat loss and gains. While there are some easy improvements, like fixing broken windows or leaky doors, many building envelope projects require large investments and become difficult to justify on a return on investment basis.

The roof and walls, windows and doors are the most obvious places to look for energy losses. The five critical areas for building envelope energy improvements are:

Infiltration is air leaking through openings or cracks around building components. It is one of the easiest losses to locate and fix.

Poor insulation lets heat leak into or out of the building, primarily through the walls and roof.

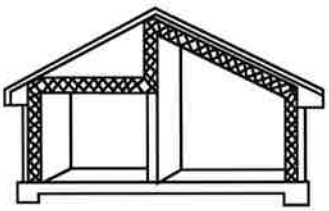
Single pane windows have extremely low resistance to heat loss or gain.

Lack of shading increases solar loads in the summer and increases air conditioning costs.

The HVAC equipment allows losses through piping, ductwork, stacks, dampers and rooftop units.

Here are the most important things you can do to improve the building envelope:

A. Infiltration. Find and seal leaks. This is most easily done on a day when there is a large difference between inside and outside temperature. This can also be done by using fans to create a pressure differential between the indoor and outdoor areas. You should be able to walk around the facility and look for cracks and feel for drafts. Ask employees where they feel drafts. The worst culprits are around windows and door frames, and any area where dissimilar building materials meet, like where a metal door frame meets mortar around brick. Start fixing the largest and easiest to fix leaks. Use high quality caulk to fill small gaps, and use materials like glass fiber insulation to fill larger openings.



Tighten window and door frames and install weather-stripping to reduce air leaks. Replace broken windows, and adjust any automatic door openers/closers to ensure they close quickly and completely. If your facility has window air conditioners, cover them in the off-season and make sure they are sealed tightly in the window frames.

In some instances, a vestibule, where two sets of doors create an air lock, can dramatically reduce air flows related to people entering and leaving the school. They are especially beneficial when there are lots of door openings, particularly in windy locations. Adding a vestibule can be cost prohibitive, but you may be able to create a low-cost version by adding another set of doors inside the external doors.

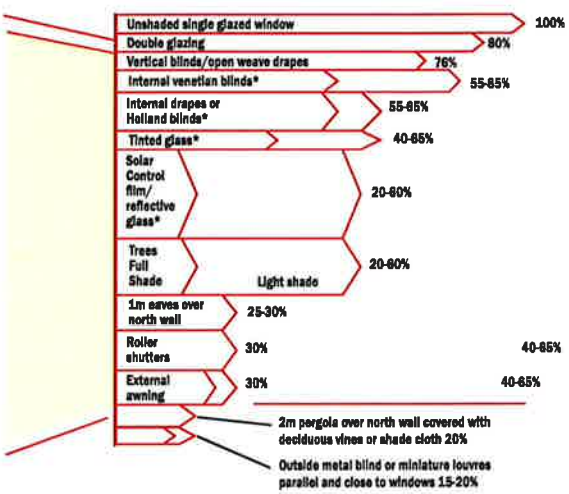
B. Poor Insulation. Add insulation to reduce heat flow through the building components. The place to begin is assessing what is there now. If there is none, the most cost-effective place to begin is probably the roof, then the walls and floors. Because these measures often require a large investment, you may want to consult with an energy specialist to run a building simulation and estimate savings.

C. Window Treatment. While they are beautiful to look at, windows are virtually thermal holes in the building envelope. Consider that a wall might have a resistance to heat flow, or R-value, of 19. A single pane window has an R-value of less than 1, almost 20 times less resistance to heat flow!

Double panes (R-2) and triple panes (R-3) do improve the situation, they double or triple the window's R-value, but by comparison to even a wall, this is not much of a heat flow barrier. Often the best you can do with windows is covering them with shades or curtains that increase their resistance to heat flow.

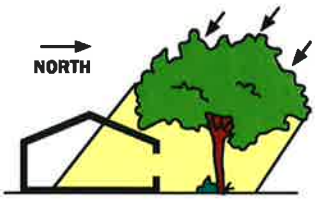
Other options include applying reflective films to windows to reduce glare and heat transfer. These films have the disadvantage of reducing natural light and solar heating in cooler months.

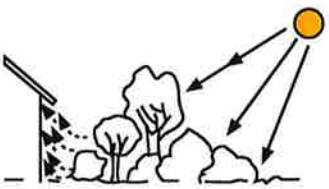
Effectiveness of various window treatments



**Effectiveness is reduced as the colour darkens.*

Shading awnings and shutter reduce radiant heat passing through windows





From School Cooling, Ministry of Education (Schools Division) Victoria, 1986. Reproduced with permission of the Department of Education, Employment and Training (DT&T).

D. Shading. Reducing heat gain through windows can reduce cooling costs, but can also increase occupant comfort. Particularly in warm climates, protecting windows from the sun can have a big impact. The first principle of shading is begin as far from the building as practical and move in. That means planting deciduous shade trees or building trellises for vines to create summer shade. Deciduous vegetation is best because it drops its leaves in winter when the extra solar gain is appreciated. Awnings are also an option.

Hot Water

Water heating in schools is needed for public restrooms, janitorial work, cafeteria, locker room showers, and occasionally swimming pools. Schools are now adapting to solar water heater systems to maximize energy savings and reduce dependence on boiler systems. Solar water heater systems have proven to be effective in schools due to their limited hours of operation.

Here are some basic thumb rules to follow during assessing requirements to install a SWHS –

The primary requirement for installation of Solar Water Heating System is a shadow free area with clear access to the South sky.

Total no. of collectors per 1000 liters:

	N. India & Hilly Regions.	Rest of India.
For 60°C	10	8
For 70°C	12	10
For 80°C	15	12

Flat/Roof Area required for installing SWHS

- Each solar collector measuring 2m x 1m requires 3.5 sqm of flat surface inclusive of hot water storage tank and interconnecting piping.

For every **1000 liters of water heated from room temperature (25°C) to 80°C, approximate equivalent energy savings per day** are as follows (Source – "Driving Towards Energy Independence" – TATA BP Solar):

Electricity: 45 Units
Diesel: 5.3 Liters

The table provided below provides a comparison snapshot of savings based on the selected SWHS capacity -

Table1 - Comparison Snapshot of Savings Based on the Selected SWHS Capacity (Source – "Driving Towards Energy Independence" – TATA BP Solar)

Capacity lpd	Total no. of collectors	Area - 800C Sqm	Elec Savings (Units/day)	Savings/Yr (@Rs5/Unit)	Savings/Yr (Diesel)
1000	10	35	45	67,500	52,500
2000	20	70	90	135,000	105,000
3000	30	105	135	202,500	157,500
4000	40	140	180	270,000	210,000
5000	50	175	225	337,500	262,500
6000	60	210	270	405,000	315,000
7000	70	245	315	472,500	367,500
8000	80	280	360	540,000	420,000
9000	90	315	405	607,500	472,500
10000	100	350	450	675,000	525,000
15000	150	525	675	1,012,500	787,500
20000	200	700	900	1,350,000	1,050,000
25000	250	875	1125	1,687,500	1,312,500
30000	300	1050	1350	2,025,000	1,575,000

* *Approximated*

Irrespective of the heating system utilized in your school, listed below are some inexpensive and easy measures that can reduce your water heating costs.

B. Reduce Hot Water Use. Install flow restrictors and aerators in sink faucets. Don't install them in areas like janitor's closets where they are used for filling buckets where filling speed is important. Install low-flow showerheads to reduce hot water usage. Some showerheads, particularly older ones, have flow rates of more than 5 gallons per minute, while low-flow models are half that amount. Check the flow rates in the showers by turning on the shower to a normal flow rate and timing how long it takes to fill a gallon bucket. Install self-closing faucets in public restrooms.

C. Reduce Heat Loss. If the tank is warm to the touch, it is losing valuable heat to the surroundings 24 hours a day and needs a tank wrap or blanket. Blankets are inexpensive and easy to install, and are readily available at hardware stores. Also insulate the exposed hot water piping, and repair or replace any existing insulation.

D. Label Faucets. Remind staff, students, and visitors of your conservation effort by posting labels asking them to "Please turn off the water." If continuously running water is a problem, install self-closing faucets where you push down on a lever for 10 to 15 seconds of water flow. Also, occupancy sensing controls typically consisting of a photo cell and solenoids can be installed above sinks to control water flow.

E. Maintain the System. Fix hot water leaks. Check and adjust the fuel-fired systems to be sure they are burning properly. Have a service technician check it out and clean it once a year. Drain any sediment from the bottom of tank water heaters by letting a little water out until it runs clear. When left to accumulate, the sediment forms a layer of insulation at the bottom of the tank, where with fuel-fired systems; heat transfer is trying to take place.

Integrating Energy Management Into A School's Culture

In addition to improving systems, a successful energy management program needs to be imbibed into the school culture. There is a significant human factor involved in all operations and maintenance programs.

New staff energy management training: Any new staff member across departments must be introduced to the school's energy management culture. Developing a brief energy management training will help instill energy management as a department-wide value and teach staff how to use energy more efficiently in their respective areas. Reinforcing this orientation training with regular energy management seminars, brochures, or other visibility will ensure that the initial training stays with staff.

Educating new and existing students on importance of energy management: Motivating students to participate in an energy management program is crucial to the success of any related activity. Student orientation can be conducted for both existing and new students. Existing students can be reached out to through the inclusion of energy savings programs as an extra curricular activity. "Student Patrols" can be formed where higher grade students work with elementary students to patrol school premises and identify areas for energy savings. Developing a brief introduction to the schools' energy management program is also essential for incoming students (depending on their grade level) and their parents.

Tracking and reporting energy consumption to all staff and students: Tracking and recording energy consumption throughout the school building(s) at regular intervals (monthly) can serve as a tool for reinforcing the importance of energy management, since consumption spikes in energy and water use can be more quickly identified and resolved while tracking weekly/monthly use.

Creating a culture of continuous improvement: Make energy efficiency an integral part of your staff and student culture. Encouraging leadership and visibility, tracking energy use and offering incentives will help. These aspects are described in more detail below.

a. Tracking – All efficiency efforts at the staff or student level should be recorded, tracked over time, and evaluated. A transparent data-driven program will allow participants to see their individual and collective impact on energy performance and encourage them to actively participate in charting the impact of their activities.

b. Visibility – A simple method like using a dedicated whiteboard to track daily energy data could be useful. A whiteboard that is centrally located can be used to record energy data and any factors that may influence energy use, as well as strategies to reduce energy consumption.

c. Incentives – The recognition of staff and student commitment to energy efficiency can have a strong impact on participation. The recognition can be formal or informal, ranging from something as simple as offering participants free CFL lights as a reward for reducing energy consumption by a certain percentage, to providing certificates for identifying major energy savings and process improvements.

Calculating Costs And Payback

Evaluation and calculating costs and payback period form the lifeline for an energy management program. Cost savings are a driving factor behind the longevity and success of the program. Associated savings can be used to improve the program or re-invested within the school for enhancing other services. For example, cost savings are invested in additional facilities for the school. Understanding the payback period also helps school administrative authorities assess the viability of the measures to be implemented. Please note that the payback option is primarily used as a basic calculation for each measure implemented. Determining cost effectiveness of large investments over time would require a life cycle cost or monthly flow calculations.

There are many ways associated with calculating costs and payback period. This guidebook focuses on the **"simple payback"** method, which is one of the least complicated ways to evaluate the value.

Simple Payback Method

The following calculation method and calculator has been adapted from the energy management guide "Managing Energy in Your Hotel". The calculator can be modified to include variables specific to your school.

The simple payback method involves calculating the simple payback by dividing the cost of the improvement by the annual energy savings. The result is the number of years to payback the investment from the energy savings.

This method comprises of a basic calculation and is utilized primarily for low investment measures. It doesn't take into account the time value of money, energy cost changes, tax effects if any, nor the expected life of the equipment. Please note that to make the ratio as accurate as possible, remember to subtract any rebates from the initial cost of the measure and deduct any required operating costs from the annual energy savings.

$$\textbf{Simple Payback} = \frac{\text{Cost of Measure (minus any rebates)}}{\text{Annual Energy Savings (minus any operating expenses)}}$$

Example: If installing a time clock costs INR 2,000 and saves INR 4,000 annually on energy costs, it has a 0.5 years or 6 months payback.

$$\textbf{Payback} = \frac{\text{INR 2,000}}{\text{INR 4,000/year}} = \frac{1}{2} \text{ years}$$

ELECTRIC ENERGY IMPROVEMENT PAYBACK CALCULATOR

Cost For Implementing Measures

Cost of Materials INR _____ ,

Cost of Labor INR _____ ,

Cost of Training INR _____ ,

Total Cost of Energy Saving Measures INR _____ **(A)**

Electric Usage Savings

Complete the following calculations for each measure determine your total Rupee savings and compute your payback.

Details	Old	New
(B) Watts		
(C) Hours/day		
(D) Watt-Hours/day (Multiply B & C)		
(E) Days/year		
(F) Watt-Hours/year (Multiply D & E)		
(G) Total Kilo-watt-hour (kWh)/year (F/1000)		
(H) Annual kWh Savings [(G – Old) – (G – New)]		

Annual Electricity Cost Savings

Annual kWh Savings INR _____ **(H)**

Times Electricity Cost/kWh x INR _____

Total Energy Savings INR _____ **(I)**

Less any incremental O & M Costs INR _____ **(J)**

Total Savings INR _____ **(K)**

Simple Payback In Years

$$\text{Simple Payback} = \frac{\text{Total Cost of Energy Saving Measure}}{\text{Total Savings}}$$

Energy-Efficiency Measures List

An energy efficiency checklist is provided below as a template that can be modified and used by your school. This is included to provide a quick overview of measures that you can consider for the various systems in your school.

1.0 Envelope

- Reduce Heat Losses-Ceiling/roof
  - o Better Ceiling/Roof Insulation
  - o Use Light-Colored Roof Surfaces
- Reduce Heat Losses-Walls/floors
- Use Light Colored Exterior Surfaces
- Thermal Mass/Passive Solar Heating
- Reduce Heat Losses-Windows/Doors
  - o Install Additional Glazing Layer
  - o Use Special Coatings or Gases
    - Heat mirror
    - low-e coatings
    - Argon gas window fill
- Reduce Heat Gain--Windows/Doors
  - o Install Exterior Shading
  - o Install Interior Shading
  - o Use Tinted or Reflective Coatings or Films
  - o Optimize Window Sizing and Orientation
- Reduce Infiltration
  - o Caulk and Weather strip Doors and Windows
  - o Install Air-Lock Vestibule System or Revolving Doors

2.0 Lighting

- Reduce Lighting Required
  - o Utilize Task Lighting
  - o Lighting Controls
    - Selective switching
    - Programmable timing control
    - Occupancy sensors
    - Energy management system
  - o Use Light-Colored Interior Wall Finishes
- Install More Energy-Efficient Lighting System
  - o Use High-Efficiency Fixtures
    - HID fixtures in selected locations
    - Efficient exit signs
    - Self-ballasted compact fluorescents
  - o Use Efficient Exterior Fixtures
    - High-pressure sodium HID fixtures
    - Metal halide fixtures
  - o Use High-Efficiency Ballast
    - Electromagnetic
- Use Day lighting
  - o Install Dimming Controls
  - o Architectural Modifications

3.0 HVAC Systems

- Air Distribution Systems
  - o Reduce Energy Losses
    - Increase duct insulation
    - Install air-to-air heat recovery
    - Runaround loop heat recovery
    - Reduce System Flow Rates
    - Airflow and fan speed reduction

        - VAV system to reduce fan energy use
        - Variable speed drive motor for VAV
    - Reduce System Resistance
        - High-efficiency filters
        - Improve design and balance of duct system
    - Reduce Ventilation Loads
        - Reduce ventilation rate to minimum
        - Install local ventilation and makeup air hoods
    - Air Destratification
        - Enclosed high-velocity fan
        - Open propeller fans
        - Ductwork system with centrifugal or vane axial fans

3.1 Water Distribution

- Reduce System Flow Rates
    - Primary/secondary pumping with variable speed motors
    - Isolate off-line equipment in parallel piping circuits
    - Time control or interlocks on circulating pumps
- Reduce System Resistance
    - Install booster pumps

3.2 Cooling Plant

- Select More Efficient Cooling System
    - Use evaporative cooling
    - Use cooling tower instead of air-cooled system
- Improve Cooling Efficiency
    - Optimize chiller efficiency with temperature controls
    - Use multiple chillers and optimization controls
    - Increase chilled water design temperature
    - Optimize cooling tower flow controls
- Increase Condensing Efficiency
    - Lower condenser water design temperature
    - Reset controls on water temperature
    - Tube-brush cleaning system
    - Chemical washing system
- Improve Part-Load Performance
    - Select chillers based on Integrated Part Load Value (IPLV)

4.0 Water Heating

- Reduce Water Heating Loads
    - Use solar water heating system
- Reduce System Losses
    - Increase Insulation on Hot Water Pipes
    - Increase Insulation on Water Storage Tanks

5.0 Power Systems

- Reduce Power System Losses
    - Correct Power Factors
    - Install Energy-Efficient Transformers
- Install Energy-Efficient Motors
    - High-Efficiency Motors
    - Variable Speed Motors
    - Optimize Motor Sizing

6.0 Refrigerators

- Improve efficiency
    - Buy BEE labeled energy efficient refrigerators

Glossary

Air Handling Unit (AHU):

Equipment that distributes conditioned air.

Ambient Temperature:

Outside air temperature.

Ballast:

A device used with fluorescent and other types of gaseous discharge lamps to aid starting and limit current flow and to provide voltage control at proper design levels. Can be magnetic or electronic.

British Thermal Unit (BTU):

Equal to the amount of heat energy necessary to raise the temperature of one pound of water one degree Fahrenheit. One Btu is about equal to the amount of heat given off by a wooden match.

Building Envelope:

The elements of a building which enclose conditioned spaces through which thermal energy may be transferred to or from the exterior.

Caulking:

A flexible material used to seal up cracks or spaces in a structure.

Coefficient Of Utilization:

The ratio of lumens on a work plane to lumens emitted by lamps.

Comfort Zone:

Average: The range of effective temperatures over which the majority (50 percent or more) of adults feel comfortable. Extreme: The range of effective temperatures over which one or more adults feel comfortable.

Conversion Factors:

1 Watt = 3.413 Btu/hr
1 kW = 3,413 Btu/hr
746 Watts = 1 HP (Motor)
1 Gal. Oil = 140,000 Btu
1 Lb. Coal = 12,500 Btu
1 Therm of Natural Gas = 100,000 Btu
1 Cu. ft. of Natural Gas = 1,000 Btu
1 Cu. ft. of Propane Gas = 2,500 Btu
1 Lb. of Propane Gas = 21,500 Btu
1 Ton refrigeration = 12,000 Btu/1 hr

Degree Day:

The degree day value for any given day is the difference between 65°F and the mean daily temperature. Example: for a mean daily temperature of 50°F, the degree days are 65 minus 50 or 15 degree days.

Energy Audit:

Any survey of a building, business or complex that reviews energy-using equipment or behavior.

Energy Conservation Measure (Ecm):

A permanent change made to a conditioned building after completion of operation and maintenance measures which will result in energy savings.

Energy Efficiency Ratio (EER):

The ratio of net cooling capacity in Btu/hr to total rate of electric input in watts under designated operating conditions.

Foot Candles (FC):

Energy of light at a distance of 1 ft. from a standard (sperm oil) candle.

Glazing:

Another term for glass in windows.

Horsepower (HP):

British unit of power, 1 HP = 746 W or 42.408 Btu per minute.

Insulation:

A material used to minimize heat losses from a given space.

Kilowatt Hour (Kwh):

A unit of energy equal to that expended by one kilowatt in one hour = 3,414 site Btus and 11,600 source Btus.

Infiltration:

The process by which outdoor air leaks into a building by natural forces through cracks around doors and windows, etc. (usually undesirable). Usually caused by the pressure effects of wind and/or the effect of differences in the indoor and outdoor air density.

Lumen:

Unit of light energy or output (luminous flux).

Makeup Air:

Outdoor air that is brought into a building to compensate for air removed by exhaust fans or other methods.

Multizone System:

An HVAC system that heats and cools several zones each with different load requirements from a single, central unit. A thermostat in each zone controls dampers at the unit that mix the hot and cold air to meet the varying load requirements of the zone involved.

Photo Cell:

A device sensitive to light which is now commonly used to turn on and off the lights at dusk and dawn.

Pneumatic:

Operated by air pressure.

Power:

Power is the time rate of doing work. In connection with the

transmission of energy of all types, power refers to the rate at which

energy is transmitted. In customary units it is measured in watts (W),

British Thermal Units per hour (Btu/hr), or Horsepower (HP).

Refrigeration, Ton Of:

Equivalent to the removal of heat at a rate of 200 Btu per minute, 12,000 Btu/hour, or 288,000 Btu/day.

Resistance (R-Value):

Term used to measure insulation material resistance to the flow of heat in units of square feet per hour.

Retrofit:

The improvement of existing buildings to make them more energy efficient.

Setback:

Reducing the level of heat required from the conditioning system to the lowest practical point especially during periods where the room activities or occupation allows.

Simple Payback (SPB):

Time required for an investment to pay for itself. The cost of the retrofit measure divided by the annual energy cost savings in Rs/year.

Single Zone System:

An HVAC system that supplies one level of heating or cooling to a zone or area controlled by one thermostat. The system may be installed within or remote from the space it serves, either with or without air distribution ductwork.

Thermal Barrier:

A strip of nonconducting material, such as wood, vinyl, or foam rubber, separating the inside and outside surfaces to stop conduction of heat or cold to the outside.

Ventilation:

The process of supplying or removing air, by natural or mechanical means to or from any place. Such air may or may not have been conditioned.

Weatherstripping:

Metal, plastic or felt strips designed to seal between windows and door frames to prevent air infiltration.

Zone:

A space or group of spaces within a building with heating and/or cooling requirements sufficiently similar so that comfort conditions can be maintained throughout by a single controlling device.

For further information, please contact

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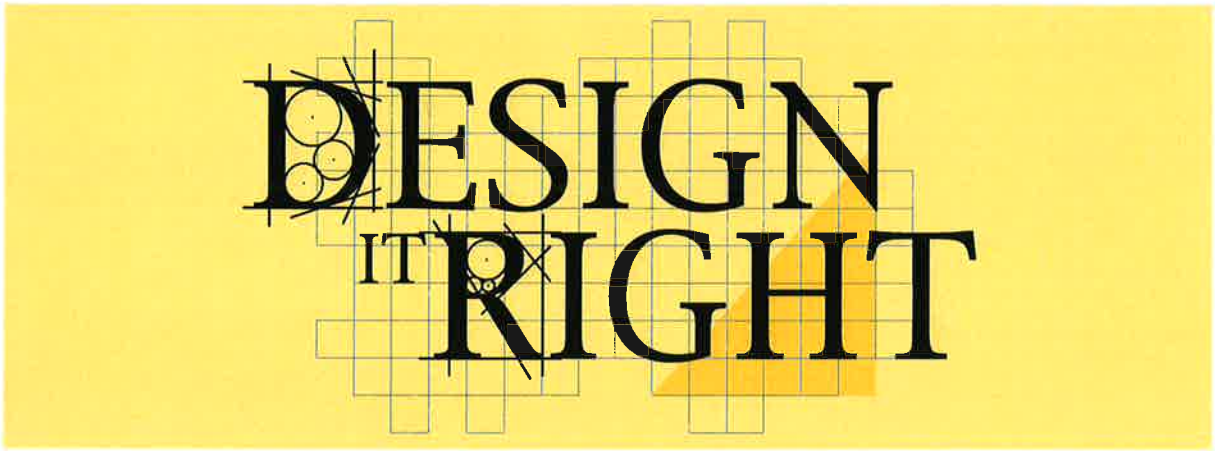
Capacitor banks and
passive harmonic filters

Power factor correction: a guide for the plant engineer



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Powering Business Worldwide

Part One: power factor

What is power factor?

Special electrical requirement of inductive loads

Most loads in modern electrical distribution systems are inductive. Examples include motors, transformers, gaseous tube lighting ballasts, and induction furnaces. Inductive loads need a magnetic field to operate.

Inductive loads require two kinds of current:

- Working power (kW) to perform the actual work of creating heat, light, motion, machine output, and so on.
- Reactive power (kVAR) to sustain the magnetic field

Working power consumes watts and can be read on a wattmeter. It is measured in kilowatts (kW). Reactive power doesn't perform useful "work," but circulates between the generator and the load. It places a heavier drain on the power source, as well as on the power source's distribution system. Reactive power is measured in kilovolt-amperes-reactive (kVAR).

Working power and reactive power together make up apparent power. Apparent power is measured in kilovolt-amperes (kVA).

Note: For a discussion on power factor in nonlinear, nonsinusoidal systems, turn to **Page 17**.

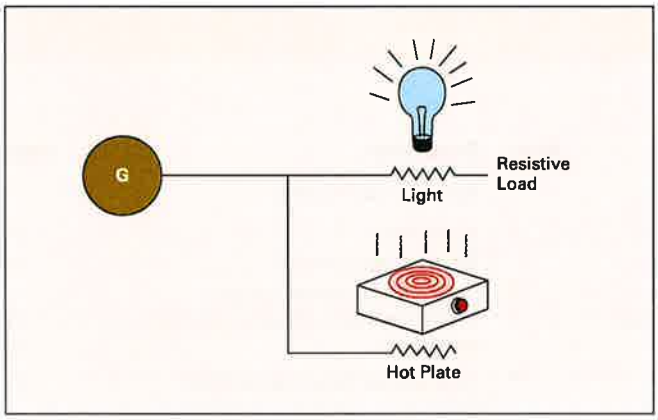


Figure 1. kW Power

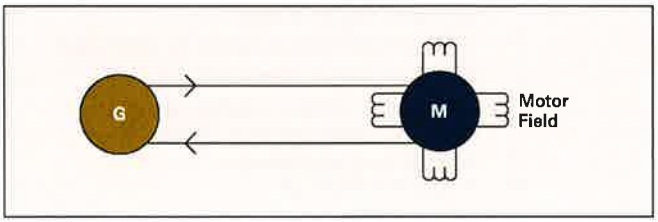


Figure 2. kVAR Power

Fundamentals of power factor

Power factor is the ratio of working power to apparent power. It measures how effectively electrical power is being used. A high power factor signals efficient utilization of electrical power, while a low power factor indicates poor utilization of electrical power.

To determine power factor (PF), divide working power (kW) by apparent power (kVA). In a linear or sinusoidal system, the result is also referred to as the cosine θ.

$$PF = \frac{kW}{kVA} = \text{cosine } \theta$$

For example, if you had a boring mill that was operating at 100 kW and the apparent power consumed was 125 kVA, you would divide 100 by 125 and come up with a power factor of 0.80.

$$\frac{(kW)\ 100}{(kVA)\ 125} = (PF)\ 0.80$$

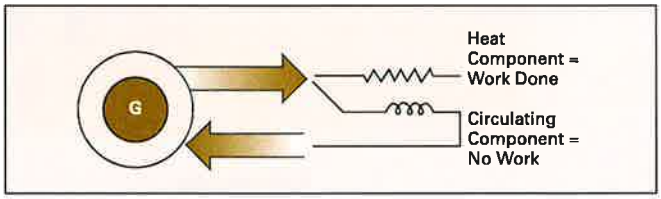


Figure 3. kVA Power

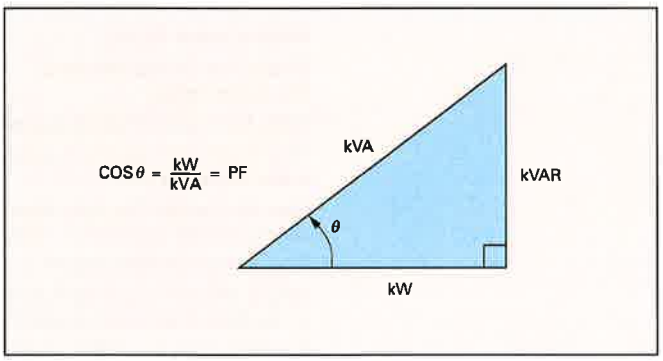


Figure 4. Power Triangle

Note: A right power triangle is often used to illustrate the relationship between kW, kVAR, and kVA.

Should I be concerned about low power factor?

Low power factor means you're not fully utilizing the electrical power you're paying for.

As the triangle relationships in **Figure 5** demonstrate, kVA decreases as power factor increases. At 70% power factor, it requires 142 kVA to produce 100 kW. At 95% power factor, it requires only 105 kVA to produce 100 kW. Another way to look at it is that at 70% power factor, *it takes 35% more current to do the same work.*

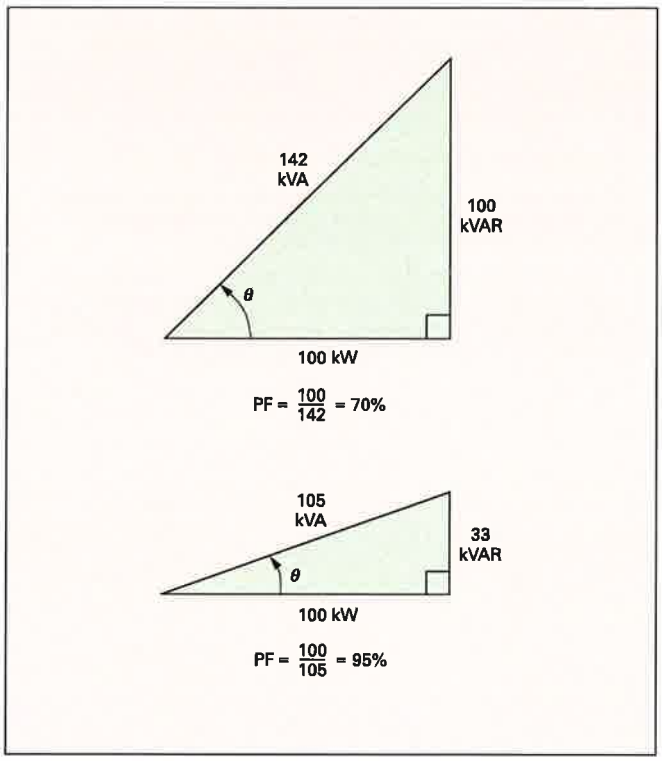


Figure 5. Typical Power Triangles

What can I do to improve power factor?

You can improve power factor by adding power factor correction capacitors to your plant distribution system.

When apparent power (kVA) is greater than working power (kW), the utility must supply the excess reactive current plus the working current. Power capacitors act as reactive current generators. (See **Figure 6**.) By providing the reactive current, they reduce the total amount of current your system must draw from the utility.

95% power factor provides maximum benefit

Theoretically, capacitors could provide 100% of needed reactive power. In practical usage, however, *power factor correction to approximately 95% provides maximum benefit.*

The power triangle in **Figure 7** shows apparent power demands on a system before and after adding capacitors. By installing power capacitors and increasing power factor to 95%, apparent power is reduced from 142 kVA to 105 kVA—*a reduction of 35%.*

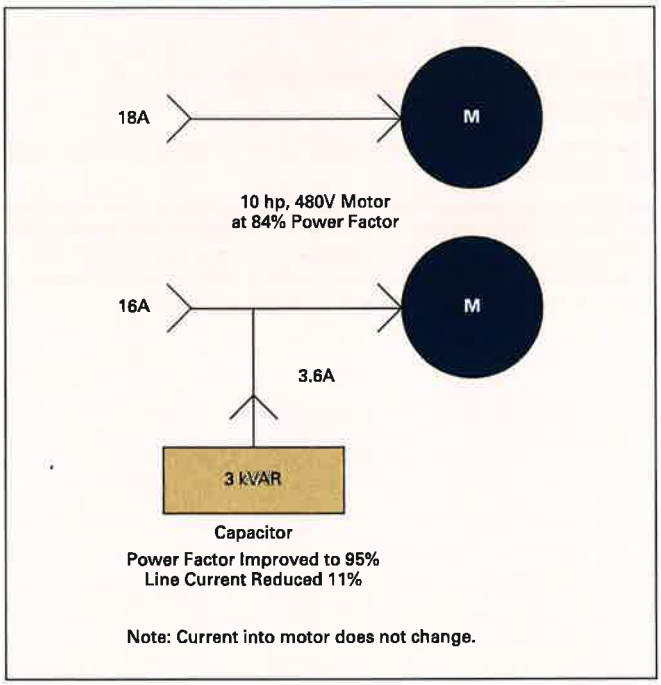


Figure 6. Capacitors as kVAR Generators

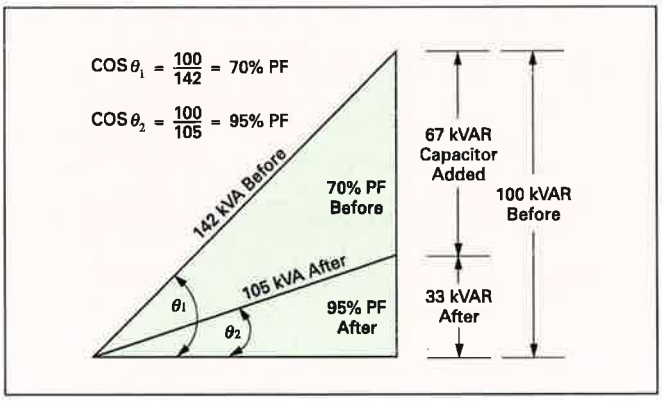


Figure 7. Required Apparent Power Before and After Adding Capacitors

How much can I save by installing power capacitors?

Power capacitors provide many benefits:

- Reduced electric utility bills
- Increased system capacity
- Improved voltage
- Reduced losses

Reduced utility bills

Your electric utility provides working (kW) and reactive power (kVAR) to your plant in the form of apparent power (kVA). While reactive power (kVAR) doesn't register on kW demand or kW hour meters, the utility's transmission and distribution system must be large enough to provide the total power. Utilities have various ways of passing the expense of larger generators, transformers, cables, switches, and the like, along to you.

As shown in the following case histories, capacitors can save you money no matter how your utility bills you for power.

kVA billing

The utility measures and bills every ampere of current, including reactive current.

Case 1

Assume an uncorrected 460 kVA demand, 480V, three-phase at 0.87 power factor (normally good).

Billing:

$4.75/kVA demand
Correct to 0.97 power factor

Solution:

kVA × power factor = kW
460 × 0.87 = 400 kW actual demand

$$\frac{kW}{PF} = kVA$$

$$\frac{400}{0.97} = 412 \text{ corrected billing demand}$$

From **Table 6** kW multipliers, to raise the power factor from 0.87 to 0.97 requires capacitor:

Multiplier of 0.316 x kW
0.316 x 400 = 126 kVAR (use 140 kVAR)

Uncorrected original billing:

460 kVA × $4.75 = $2185 / month
−$1957
$ 228 / month savings × 12
$2736 annual savings

Corrected new billing:

412 kVA × $4.75 = $1957/month

140 kVAR, 480V capacitor cost: $1600 (installation extra).
This capacitor pays for itself in less than eight months.

Case 2

Assume the same conditions except that:
400 kW @ 87% = 460 kVA
400 kW @ 97% = 412 kVA corrected billing

kVA demand charge:

$1.91 / kVA / month (112,400 kWh / month energy consumed)

Energy charge:

$0.0286 / kWh (first 200 kWh / kVA of demand)
$0.0243 / kWh (next 300 kWh / kVA of demand)
$0.021 / kWh (all over 500 kWh / kVA of demand)

Uncorrected:

460 kVA × $1.91 = $878.60
−$786.92
$ 91.68 savings in demand charge

Corrected:

412 kVA × $1.91 = $786.92

Uncorrected energy:

kWh = 112,400
460 × 200 = 92,000 kWh
@ 0.0286 = $2631.20

460 × 300 = 138,000
but balance only = 20,400
@ $0.0243 = $495.72

$2631.20
+$ 495.72
$3126.92 uncorrected energy charge

Corrected energy:

kWh = 112,400
460 × 200 = 82,400 kWh
@ 0.0286 = $2356.64

460 × 300 = 123,600
but balance only = 30,000
@ $0.0243 = $729.00

$2356.64
+$ 729.00
$3085.64 corrected energy charge

$3126.92
−$3085.64
$ 41.28 savings in energy charge due to rate charge

(9600 kWh in first step reduced by $0.0043)

This is not a reduction in energy consumed, but in billing only.

$ 41.28 energy
−$ 91.68 demand
$ 132.96 monthly total savings
× 12
$1595.52

A 130 kVAR capacitor can be paid for in less than 14 months.

kW demand billing with power factor adjustment

The utility charges according to the kW demand and adds a surcharge or adjustment for power factor. The adjustment may be a multiplier applied to kW demand. The following formula shows a billing based on 90% power factor:

$$\frac{\text{kW demand} \times 0.90}{\text{actual power factor}}$$

If power factor was 0.84, the utility would require 7% increase in billing, as shown in this formula:

$$\frac{\text{kW} \times 0.90}{0.84} = 107 \text{ (multiplier)}$$

Some utilities charge for low power factor but give a credit or bonus for power above a certain level.

Case 1

Assume a 400 kW load, 87% power factor with the following utility tariff.

Demand charges:

First 40 kW @ $10.00 / kW monthly billing demand
Next 160 kW @ $ 9.50 / kW
Next 800 kW @ $ 9.00 / kW
All over 1000 kW @ $ 8.50 / kW

Power factor clause:

Rates based on power factor of 90% or higher. When power factor is less than 85%, the demand will be increased 1% for each 1% that the power factor is below 90%. If the power factor is higher than 95%, the demand will be decreased 1% for each 1% that the power factor is above 90%.

There would be no penalty for 87% power factor. However, a bonus could be credited if the power factor were raised to 96%.

To raise an 87% power factor to 96%, refer to **Table 6**. Find 0.275 x 400 kW = 110 kVAR. (Select 120 kVAR to ensure the maintenance of the 96% level.)

To calculate savings:

Normal 400 kW billing demand

First	40 kW	@ $10.00 =	$ 400.00
Next	160 kW	@ $ 9.50 =	$1520.00
Bal.	200 kW	@ $ 9.00 =	$1800.00
Total	400 kW		$3720.00 normal monthly billing

New billing:

$$\frac{\text{kW} \times 0.90}{\text{New power factor}} = \frac{400 \times 0.90}{0.96} = 375 \text{ kW demand}$$

First	40 kW	@ $10.00 =	$ 400.00
Next	160 kW	@ $ 9.50 =	$1520.00
Bal.	175 kW	@ $ 9.00 =	$1575.00
			$3495.00 power factor adjusted billing

Case 2

With the same 400 kW load, the power factor is only 81%. In this example, the customer will pay an adjustment on:

$$\frac{400 \times 0.90}{0.81} = 444 \text{ billing kW demand}$$

(From Case 1: When the power factor = 96%, the billing demand is 375 kW = $3495.00 per month.)

First	40 kW	@ $10.00 =	$ 400.00
Next	160 kW	@ $ 9.50 =	$1520.00
Next	244 kW	@ $ 9.00 =	$2196.00
Total	444 kW		$4116.00 – $3495.00 = $621.00 x 12
			= $7452.00

Yearly savings if corrected to 96%.

$4116.00 Charge at 81%
–$3720.00 Normal kW demand charge
$ 395.00 Power factor adjustment for 81% power factor ❶

To raise 81% power factor to 96%, select the multiplier from **Table 6**. 0.432 x 400 kW = 173 kVAR. Use 180 kVAR to ensure a 96% power factor. The cost of a 180 kVAR capacitor is $1900.00, and the payoff is less than four months.

❶ 55 kVAR would eliminate the penalty by correcting power factor to 85%.

kVAR reactive demand charge

The utility imposes a direct charge for the use of magnetizing power, usually a waiver of some percentage of kW demand. For example, if this charge were 60 cents per kVAR for everything over 50% of kW, and a 400 kW load existed at the time, the utility would provide 200 kVAR free.

Case 1

Assume a 400 kW load demand at 81% power factor.

Tariff structure:

Demand charge is:

$635.00 for the first 200 kW demand
$ 2.80 per kW for all addition

Reactive demand charge is:

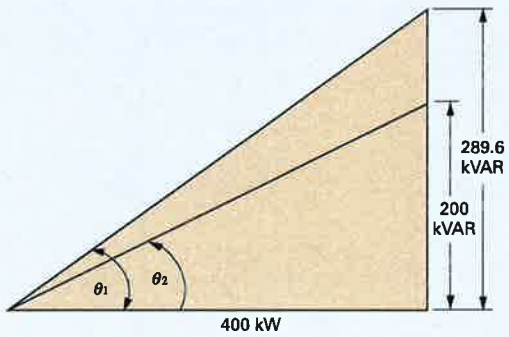
$ 0.60 per kVAR in excess of 50% of kW demand

In this example, kW demand = 400 kW,
therefore 50% = 200 kVAR which will be furnished at no cost.

$$\text{Cos } \theta = \text{PF} = \frac{\text{kW}}{\text{kVA}} \text{ or } \frac{\text{Adj}}{\text{Hyp}}$$

$$\text{Tan } \theta = \frac{\text{kvar}}{\text{kW}} \text{ or } \frac{\text{Opp}}{\text{Adj}}$$

This ratio is the basis for the table of Multipliers (See **Table 5**).



With 200 kVAR allowed at no cost, then

$$\theta_2 = \frac{200}{400} \quad 0.5 \text{ or } 50\% \text{ of kW}$$

From 1.0 or unity power factor column, **Table 6**, note that 0.500 falls between 89% and 90% power factor. The billing excess kVAR is above that level 81% power factor.

Tan θ_1 = 0.724 kVAR = kW x Tan θ_1 = 400 x 0.724 = 289.6 kVAR

Because 200 kVAR is allowed, the excess kVAR is 89.6 (round to 90) x $0.60 = $54.00 per month billing for reactive demand.

Solution:

To correct 400 kW from 81% to 90% requires 400 x 0.240 (from **Table 6**) = 96 kVAR. (Use 100 kVAR.) The approximate cost for this capacitor is $1250.00. The payoff is about 23 months.

Charges for kVAR vary from about 15 cents to a dollar, and free kVAR ranges from 25% (97% power factor) to 75% (80% power factor) of kW demand.

Increased system capacity

Power factor correction capacitors increase system current-carrying capacity. Raising the power factor on a kW load reduces kVA. Therefore, by adding capacitors, you can add additional kW load to your system without altering the kVA.

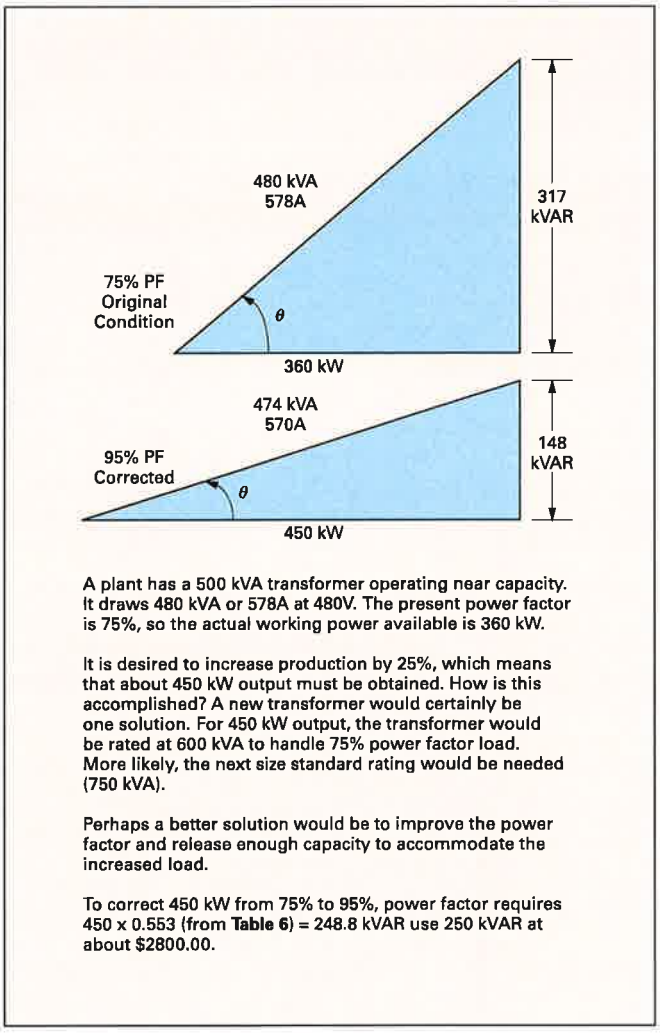


Figure 8. Correcting Power Factor Increases Transformer Output

The same principle holds true for reducing current on overloaded facilities. Increasing power factor from 75% to 95% on the same kW load results in 21% lower current flow. Put another way, it takes 26.7% more current for a load to operate at 75%, and 46.2% more current to operate at 65%.

Industries with low power factor benefit most from capacitors

Low power factor results when inactive motors are operated at less than full load. This often occurs in cycle processes—such as those using circular saws, ball mills, conveyors, compressors, grinders, punch presses, and the like—where motors are sized for the heaviest load. Examples of situations where low power factor (from 30% to 50%) occur include a surface grinder performing a light cut, an unloaded air compressor, and a circular saw spinning without cutting.

The following industries typically exhibit low power factors:

Table 1. Typical Low Power Factor Industries

Industry	Uncorrected Power Factor
Saw mills	45%–60%
Plastic (especially extruders)	55%–70%
Machine tools, stamping	60%–70%
Plating, textiles, chemicals, breweries	65%–75%
Hospitals, granaries, foundries	70%–80%

Include power capacitors in new construction and expansion plans

Including power capacitors in your new construction and expansion plans can reduce the size of transformers, bus, switches, and the like, and bring your project in at lower cost.

Figure 9 shows how much system kVA can be released by improving power factor. Raising the power factor from 70% to 90% releases 0.32 kVA per kW. On a 400 kW load, 128 kVA is released.

Improved voltage conditions

Low voltage, resulting from excessive current draw, causes motors to be sluggish and overheated. As power factor decreases, total line current increases, causing further voltage drop. By adding capacitors to your system and improving voltage, you get more efficient motor performance and longer motor life.

Reduced losses

Losses caused by poor power factor are due to reactive current flowing in the system. These are watt-related charges and can be eliminated through power factor correction. Power loss (watts) in a distribution system is calculated by squaring the current and multiplying it by the circuit resistance (12R). To calculate loss reduction:

$$\% \text{ reduction losses} = 100 - 100 \times \left(\frac{\text{original power factor}}{\text{new power factor}}\right)^2$$

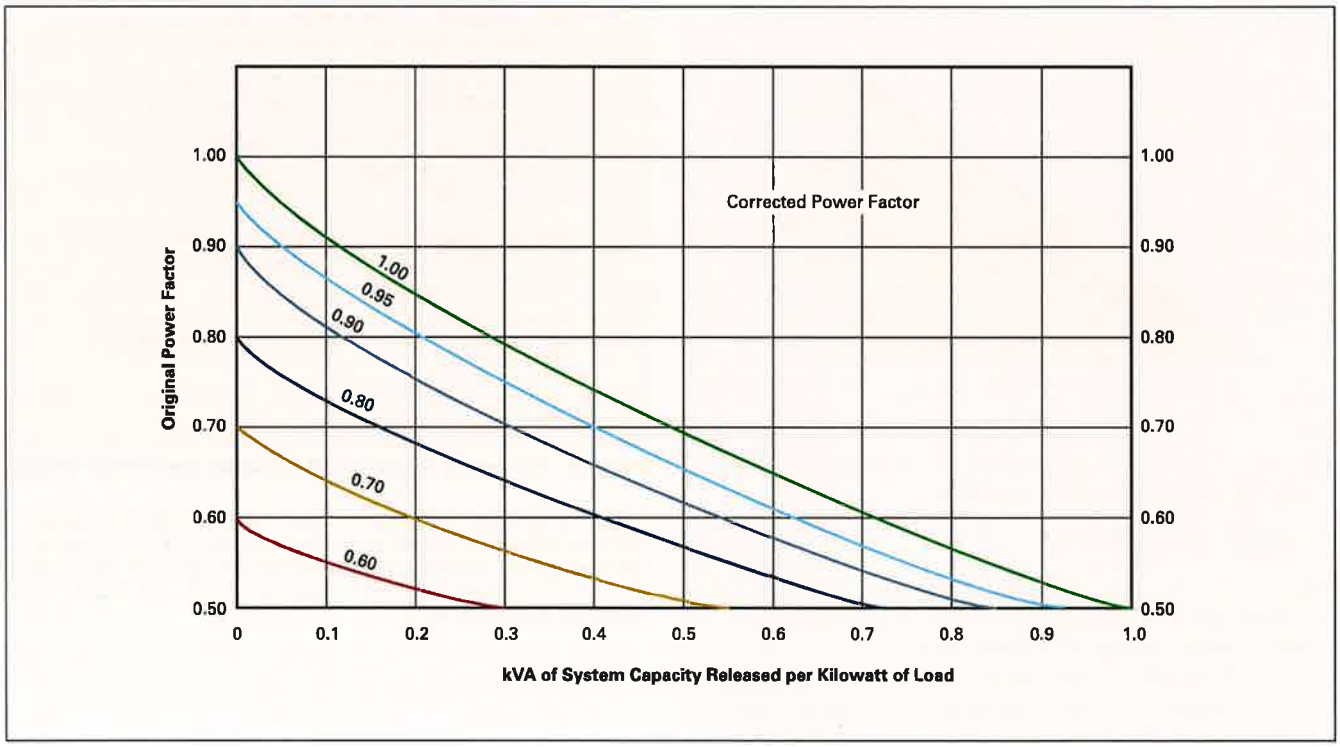


Figure 9. Corrected Power Factor Releases System kVA

How can I select the right capacitors for my specific application needs?

Once you've decided that your facility can benefit from power factor correction, you'll need to choose the optimum type, size, and number of capacitors for your plant.

There are two basic types of capacitor installations: individual capacitors on linear or sinusoidal loads, and banks of fixed or automatically switched capacitors at the feeder or substation.

Individual vs. banked installations

Advantages of individual capacitors at the load:

- Complete control; capacitors cannot cause problems on the line during light load conditions
- No need for separate switching; motor always operates with capacitor
- Improved motor performance due to more efficient power use and reduced voltage drops
- Motors and capacitors can be easily relocated together
- Easier to select the right capacitor for the load
- Reduced line losses
- Increased system capacity

Advantages of bank installations at the feeder or substation:

- Lower cost per kVAR
- Total plant power factor improved—reduces or eliminates all forms of kVAR charges
- Automatic switching ensures exact amount of power factor correction, eliminates over-capacitance and resulting overvoltages

Table 2. Summary of Advantages/Disadvantages of Individual, Fixed Banks, Automatic Banks, Combination

Method	Advantages	Disadvantages
Individual capacitors	Most technically efficient, most flexible	Higher installation and maintenance cost
Fixed bank	Most economical, fewer installations	Less flexible, requires switches and/or circuit breakers
Automatic bank	Best for variable loads, prevents overvoltages, low installation cost	Higher equipment cost
Combination	Most practical for larger numbers of motors	Least flexible

Consider the particular needs of your plant

When deciding which type of capacitor installation best meets your needs, you'll have to weigh the advantages and disadvantages of each and consider several plant variables, including load type, load size, load constancy, load capacity, motor starting methods, and manner of utility billing.

Load type

If your plant has many large motors, 50 hp and above, it is usually economical to install one capacitor per motor and switch the capacitor and motor together. If your plant consists of many small motors, 1/2 to 25 hp, you can group the motors and install one capacitor at a central point in the distribution system. Often, the best solution for plants with large and small motors is to use both types of capacitor installations.

Load size

Facilities with large loads benefit from a combination of individual load, group load, and banks of fixed and automatically-switched capacitor units. A small facility, on the other hand, may require only one capacitor at the control board.

Sometimes, only an isolated trouble spot requires power factor correction. This may be the case if your plant has welding machines, induction heaters, or DC drives. If a particular feeder serving a low power factor load is corrected, it may raise overall plant power factor enough that additional capacitors are unnecessary.

Load constancy

If your facility operates around the clock and has a constant load demand, fixed capacitors offer the greatest economy. If load is determined by eight-hour shifts five days a week, you'll want more switched units to decrease capacitance during times of reduced load.

Load capacity

If your feeders or transformers are overloaded, or if you wish to add additional load to already loaded lines, correction must be applied at the load. If your facility has surplus amperage, you can install capacitor banks at main feeders. If load varies a great deal, automatic switching is probably the answer.

Utility billing

The severity of the local electric utility tariff for power factor will affect your payback and ROI. In many areas, an optimally designed power factor correction system will pay for itself in less than two years.

How much kVAR do I need?

The unit for rating power factor capacitors is a kVAR, equal to 1000 volt-amperes of reactive power. The kVAR rating signifies how much reactive power the capacitor will provide.

Sizing capacitors for individual motor loads

To size capacitors for individual motor loads, use **Table 3** on the following page. Simply look up the type of motor frame, RPM, and horsepower. The charts indicate the kVAR rating you need to bring power factor to 95%. The charts also indicate how much current is reduced when capacitors are installed.

Sizing capacitors for entire plant loads

If you know the total kW consumption of your plant, its present power factor, and the power factor you're aiming for, you can use **Table 6**, on **Page 13** to select capacitors.

Table 3. Suggested Maximum Capacitor Ratings

Induction Motor hp Rating	Number of Poles and Nominal Motor Speed in RPM											
	2–3600 RPM		4–1800 RPM		6–1200 RPM		8–900 RPM		10–720 RPM		12–600 RPM	
	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %
Used for High-Efficiency Motors and Older Design (Pre "T-Frame") Motors ⓘ												
3	1.5	14	1.5	15	1.5	20	2	27	2.5	35	3	41
5	2	12	2	13	2	17	3	25	4	32	4	37
7.5	2.5	11	2.5	12	3	15	4	22	5	30	6	34
10	3	10	3	11	3	14	5	21	6	27	7.5	31
15	4	9	4	10	5	13	6	18	8	23	9	27
20	5	9	5	10	6	12	7.5	16	9	21	12.5	25
25	6	9	6	10	7.5	11	9	15	10	20	15	23
30	7	8	7	9	9	11	10	14	12.5	18	17.5	22
40	9	8	9	9	10	10	12.5	13	15	16	20	20
50	12.5	8	10	9	12.5	10	15	12	20	15	25	19
60	15	8	15	8	15	10	17.5	11	22.5	15	27.5	19
75	17.5	8	17.5	8	17.5	10	20	10	25	14	35	18
100	22.5	8	20	8	25	9	27.5	10	35	13	40	17
125	27.5	8	25	8	30	9	30	10	40	13	50	16
150	30	8	30	8	35	9	37.5	10	50	12	50	15
200	40	8	37.5	8	40	9	50	10	60	12	60	14
250	50	8	45	7	50	8	60	9	70	11	75	13
300	60	8	50	7	60	8	60	9	80	11	90	12
350	60	8	60	7	75	8	75	9	90	10	95	11
400	75	8	60	6	75	8	85	9	95	10	100	11
450	75	8	75	6	80	8	90	9	100	9	110	11
500	75	8	75	6	85	8	100	9	100	9	120	10
"T-Frame" NEMA® "Design B" Motors ❶												
2	1	14	1	24	1.5	30	2	42	2	40	3	50
3	1.5	14	1.5	23	2	28	3	38	3	40	4	49
5	2	14	2.5	22	3	26	4	31	4	40	5	49
7.5	2.5	14	3	20	4	21	5	28	5	38	6	45
10	4	14	4	18	5	21	6	27	7.5	36	8	38
15	5	12	5	18	6	20	7.5	24	8	32	10	34
20	6	12	6	17	7.5	19	9	23	10	29	12.5	30
25	7.5	12	7.5	17	8	19	10	23	12.5	25	17.5	30
30	8	11	8	16	10	19	15	22	15	24	20	30
40	12.5	12	15	16	15	19	17.5	21	20	24	25	30
50	15	12	17.5	15	20	19	22.5	21	22.5	24	30	30
60	17.5	12	20	15	22.5	17	25	20	30	22	35	28
75	20	12	25	14	25	15	30	17	35	21	40	19
100	22.5	11	30	14	30	12	35	16	40	15	45	17
125	25	10	35	12	35	12	40	14	45	15	50	17
150	30	10	40	12	40	12	50	14	50	13	60	17
200	35	10	50	11	50	11	70	14	70	13	90	17
250	40	11	60	10	60	10	80	13	90	13	100	17
300	45	11	70	10	75	12	100	14	100	13	120	17
350	50	12	75	8	90	12	120	13	120	13	135	15
400	75	10	80	8	100	12	130	13	140	13	150	15
450	80	8	90	8	120	10	140	12	160	14	160	15
500	100	8	120	9	150	12	160	12	180	13	180	15

❶ For use with three-phase, 60 Hz NEMA Classification B Motors to raise full load power factor to approximately 95%.

Table 4. Suggested Capacitor Ratings, in kVARs, for NEMA Design C and D, and Wound-Rotor Motors

	Design C Motor		Design D Motor	
Induction Motor Rating (hp)	1800 and 1200 r/Minimum	900 r/Minimum	1200 r/Minimum	Wound-Rotor Motor
15	5	5	5	5.5
20	5	6	6	7
25	6	6	6	7
30	7.5	9	10	11
40	10	12	12	13
50	12	15	15	17.5
60	17.5	18	18	20
75	19	22.5	22.5	25
100	27	27	30	33
125	35	37.5	37.5	40
150	37.5	45	45	50
200	45	60	60	65
250	54	70	70	75
300	65	90	75	85

Note: Applies to three-phase, 60 Hz motors when switched with capacitors as single unit.

Note: Use motor manufacturer's recommended kVAR as published in the performance data sheets for specific motor types: drip-proof, TEFC, severe duty, high-efficiency, and NEMA design.

Table 5. Suggested Capacitor Ratings for Medium Voltage Motors

	Number of Poles and Nominal Motor Speed in RPM											
	2–3600 RPM		4–1800 RPM		6–1200 RPM		8–900 RPM		10–720 RPM		12–600 RPM	
Induction Motor hp Rating	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %	Capacitor kVAR	Current Reduction %
2400 and 4160V—Open												
100	25	8	25	10	25	11	25	11	25	12	25	15
125	25	7	25	9	25	10	25	10	25	11	50	15
150	25	7	25	8	25	9	25	9	25	11	50	14
200	50	7	50	8	50	9	50	9	50	10	75	14
250	50	7	50	7	50	8	75	9	75	10	75	14
300	50	7	50	7	75	8	75	9	75	9	100	13
350	50	6	50	6	75	8	75	9	75	9	100	12
400	75	6	75	6	75	7	100	9	100	9	100	11
450	75	6	75	6	75	6	100	9	100	9	125	10
500	75	5	75	6	100	6	125	9	125	9	125	9
600	75	5	100	6	100	6	125	8	150	9	150	9
700	100	5	100	6	125	6	150	8	150	8	150	8
800	100	5	150	6	150	6	150	7	200	8	200	8
900	125	5	150	6	200	6	200	7	250	8	250	8
1000	150	5	200	6	250	5	250	6	250	7	250	7
1250	200	5	200	5	250	5	300	6	300	6	300	6
2400 and 4160V—Totally Enclosed Fan Cooled												
100	25	7	25	8	25	9	25	11	25	11	25	13
125	25	7	25	7	25	8	25	11	25	11	50	13
150	25	6	25	7	25	8	50	11	50	11	50	13
200	50	6	50	7	50	8	50	11	50	11	75	13
250	50	6	50	7	50	8	75	11	75	11	75	13
300	50	6	50	7	75	8	75	10	100	11	100	13
350	75	6	75	7	100	8	100	10	100	11	125	13
400	75	6	75	7	100	8	100	10	100	11	150	13
450	75	6	100	7	100	8	125	10	125	11	150	13
500	100	5	125	7	125	7	150	10	150	11	150	13

Above sizes are intended to provide a corrected power factor of approximately 95% at full load. Because of the limited number of capacitor ratings available, it is not possible to raise every motor PF to 95%.

To calculate kVAR required to correct power factor to a specific target value, use the following formula:

$$kVAR_{(required)} = \frac{hp \times 0.746}{\%\ EFF}\left(\frac{\sqrt{1-PFa^2}}{PFa} - \frac{\sqrt{1-PFt^2}}{PFt}\right)$$

Where

hp: motor nameplate horsepower
%EFF: motor nameplate efficiency (enter the value in decimal)
PFa: motor nameplate actual power factor
PFt: target power factor

Note: Consult the motor manufacturer's data sheet to verify the maximum kVAR of capacitors that can be directly connected at motor terminals. To avoid self-excitation, do not exceed the maximum kVAR rating that is specified by the motor manufacturer.

Instructions for Table 6 on Page 13:

1. Find the present power factor in column one.
2. Read across to optimum power factor column.
3. Multiply that number by kW demand.

Example:

If your plant consumes 410 kW, is currently operating at 73% power factor, and you want to correct power factor to 95%, you would:

1. Find 0.73 in column one.
2. Read across to 0.95 column.
3. Multiply 0.607 by 410 = 249 (round to 250).
4. You need 250 kVAR to bring your plant to 95% power factor.

If you don't know the existing power factor level of your plant, you will have to calculate it before using **Table 6** on the following page. To calculate existing power factor: kW divided by kVA = power factor.

Table 6. Multipliers to Determine Capacitor Kilovars Required for Power Factor Correction

Original Power Factor	Corrected Power Factor																				
	0.8	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.9	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.0
0.50	0.982	1.008	1.034	1.060	1.086	1.112	1.139	1.165	1.192	1.220	1.248	1.276	1.306	1.337	1.369	1.403	1.440	1.481	1.529	1.589	1.732
0.51	0.937	0.962	0.989	1.015	1.041	1.067	1.094	1.120	1.147	1.175	1.203	1.231	1.261	1.292	1.324	1.358	1.395	1.436	1.484	1.544	1.687
0.52	0.893	0.919	0.945	0.971	0.997	1.023	1.050	1.076	1.103	1.131	1.159	1.187	1.217	1.248	1.280	1.314	1.351	1.392	1.440	1.500	1.643
0.53	0.850	0.876	0.902	0.928	0.954	0.980	1.007	1.033	1.060	1.088	1.116	1.144	1.174	1.205	1.237	1.271	1.308	1.349	1.397	1.457	1.600
0.54	0.809	0.835	0.861	0.887	0.913	0.939	0.966	0.992	1.019	1.047	1.075	1.103	1.133	1.164	1.196	1.230	1.267	1.308	1.356	1.416	1.559
0.55	0.769	0.795	0.821	0.847	0.873	0.899	0.926	0.952	0.979	1.007	1.035	1.063	1.093	1.124	1.156	1.190	1.227	1.268	1.316	1.376	1.519
0.56	0.730	0.756	0.782	0.808	0.834	0.860	0.887	0.913	0.940	0.968	0.996	1.024	1.054	1.085	1.117	1.151	1.188	1.229	1.277	1.337	1.480
0.57	0.692	0.718	0.744	0.770	0.796	0.822	0.849	0.875	0.902	0.930	0.958	0.986	1.016	1.047	1.079	1.113	1.150	1.191	1.239	1.299	1.442
0.58	0.655	0.681	0.707	0.733	0.759	0.785	0.812	0.838	0.865	0.893	0.921	0.949	0.979	1.010	1.042	1.076	1.113	1.154	1.202	1.262	1.405
0.59	0.619	0.645	0.671	0.697	0.723	0.749	0.776	0.802	0.829	0.857	0.885	0.913	0.943	0.974	1.006	1.040	1.077	1.118	1.166	1.226	1.369
0.60	0.583	0.609	0.635	0.661	0.687	0.713	0.740	0.766	0.793	0.821	0.849	0.877	0.907	0.938	0.970	1.004	1.041	1.082	1.130	1.190	1.333
0.61	0.549	0.575	0.601	0.627	0.653	0.679	0.706	0.732	0.759	0.787	0.815	0.843	0.873	0.904	0.936	0.970	1.007	1.048	1.096	1.156	1.299
0.62	0.516	0.542	0.568	0.594	0.620	0.646	0.673	0.699	0.726	0.754	0.782	0.810	0.840	0.871	0.903	0.937	0.974	1.015	1.063	1.123	1.266
0.63	0.483	0.509	0.535	0.561	0.587	0.613	0.640	0.666	0.693	0.721	0.749	0.777	0.807	0.838	0.870	0.904	0.941	0.982	1.030	1.090	1.233
0.64	0.451	0.474	0.503	0.529	0.555	0.581	0.608	0.634	0.661	0.689	0.717	0.745	0.775	0.806	0.838	0.872	0.909	0.950	0.998	1.068	1.201
0.65	0.419	0.445	0.471	0.497	0.523	0.549	0.576	0.602	0.629	0.657	0.685	0.713	0.743	0.774	0.806	0.840	0.877	0.918	0.966	1.026	1.169
0.66	0.388	0.414	0.440	0.466	0.492	0.518	0.545	0.571	0.598	0.626	0.654	0.682	0.712	0.743	0.775	0.809	0.846	0.887	0.935	0.995	1.138
0.67	0.358	0.384	0.410	0.436	0.462	0.488	0.515	0.541	0.568	0.596	0.624	0.652	0.682	0.713	0.745	0.779	0.816	0.857	0.905	0.965	1.108
0.68	0.328	0.354	0.380	0.406	0.432	0.458	0.485	0.511	0.538	0.566	0.594	0.622	0.652	0.683	0.715	0.749	0.786	0.827	0.875	0.935	1.078
0.69	0.299	0.325	0.351	0.377	0.403	0.429	0.456	0.482	0.509	0.537	0.565	0.593	0.623	0.654	0.686	0.720	0.757	0.798	0.846	0.906	1.049
0.70	0.270	0.296	0.322	0.348	0.374	0.400	0.427	0.453	0.480	0.508	0.536	0.564	0.594	0.625	0.657	0.691	0.728	0.769	0.817	0.877	1.020
0.71	0.242	0.268	0.294	0.320	0.346	0.372	0.399	0.425	0.452	0.480	0.508	0.536	0.566	0.597	0.629	0.663	0.700	0.741	0.789	0.849	0.992
0.72	0.214	0.24.0	0.266	0.292	0.318	0.344	0.371	0.397	0.424	0.452	0.480	0.508	0.538	0.569	0.601	0.635	0.672	0.713	0.761	0.821	0.964
0.73	0.186	0.212	0.238	0.264	0.290	0.316	0.343	0.369	0.396	0.424	0.452	0.480	0.510	0.541	0.573	0.607	0.644	0.685	0.733	0.793	0.936
0.74	0.159	0.185	0.211	0.237	0.263	0.289	0.316	0.342	0.369	0.397	0.425	0.453	0.483	0.514	0.546	0.580	0.617	0.658	0.706	0.766	0.909
0.75	0.132	0.158	0.184	0.210	0.236	0.262	0.289	0.315	0.342	0.370	0.398	0.426	0.456	0.487	0.519	0.553	0.590	0.631	0.679	0.739	0.882
0.76	0.105	0.131	0.157	0.183	0.209	0.235	0.262	0.288	0.315	0.343	0.371	0.399	0.429	0.460	0.492	0.526	0.563	0.604	0.652	0.712	0.855
0.77	0.079	0.105	0.131	0.157	0.183	0.209	0.236	0.262	0.289	0.317	0.345	0.373	0.403	0.434	0.466	0.500	0.537	0.578	0.626	0.685	0.829
0.78	0.052	0.078	0.104	0.130	0.156	0.182	0.209	0.235	0.262	0.290	0.318	0.346	0.376	0.407	0.439	0.473	0.510	0.551	0.599	0.659	0.802
0.79	0.026	0.052	0.078	0.104	0.130	0.156	0.183	0.209	0.236	0.264	0.292	0.320	0.350	0.381	0.413	0.447	0.484	0.525	0.573	0.633	0.776
0.80	0.000	0.026	0.052	0.078	0.104	0.130	0.157	0.183	0.210	0.238	0.266	0.294	0.324	0.355	0.387	0.421	0.458	0.499	0.547	0.609	0.750
0.81		0.000	0.026	0.052	0.078	0.104	0.131	0.157	0.184	0.212	0.240	0.268	0.298	0.329	0.361	0.395	0.432	0.473	0.521	0.581	0.724
0.82			0.000	0.026	0.052	0.078	0.105	0.131	0.158	0.186	0.214	0.242	0.272	0.303	0.335	0.369	0.406	0.447	0.495	0.555	0.698
0.83				0.000	0.026	0.052	0.079	0.105	0.132	0.160	0.188	0.216	0.246	0.277	0.309	0.343	0.380	0.421	0.469	0.529	0.672
0.84					0.000	0.026	0.053	0.079	0.106	0.134	0.162	0.190	0.220	0.251	0.283	0.317	0.354	0.395	0.443	0.503	0.646
0.85						0.000	0.027	0.053	0.080	0.108	0.136	0.164	0.194	0.225	0.257	0.291	0.328	0.369	0.417	0.477	0.620
0.86							0.000	0.026	0.053	0.081	0.109	0.137	0.167	0.198	0.230	0.264	0.301	0.342	0.390	0.450	0.593
0.87								0.000	0.027	0.055	0.083	0.111	0.141	0.172	0.204	0.238	0.275	0.316	0.364	0.424	0.567
0.88									0.000	0.028	0.056	0.084	0.114	0.145	0.177	0.211	0.248	0.289	0.337	0.397	0.540
0.89										0.000	0.028	0.056	0.086	0.117	0.149	0.183	0.220	0.261	0.309	0.369	0.512
0.90											0.000	0.028	0.058	0.089	0.121	0.155	0.192	0.233	0.281	0.341	0.484
0.91												0.000	0.030	0.061	0.093	0.127	0.164	0.205	0.253	0.313	0.456
0.92													0.000	0.031	0.063	0.097	0.134	0.175	0.223	0.283	0.426
0.93														0.000	0.032	0.066	0.103	0.144	0.192	0.252	0.395
0.94															0.000	0.034	0.071	0.112	0.160	0.220	0.363
0.95																0.000	0.037	0.079	0.126	0.186	0.329
0.96																	0.000	0.041	0.089	0.149	0.292
0.97																		0.000	0.048	0.108	0.251
0.98																			0.000	0.060	0.203
0.99																				0.000	0.143
																					0.000

Table 7. Recommended Wire Sizes, Switches, and Fuses for Three-Phase, 60 Hz Capacitors
These wire sizes are based on 135% of rated current in accordance with the National Electrical Code®, Article 460.

	240V				480V				600V			
kVAR	Current (Amperes)	Wire Size ❶	Fuse (Amperes)	Switch (Amperes)	Current (Amperes)	Wire Size ❶	Fuse (Amperes)	Switch (Amperes)	Current (Amperes)	Wire Size ❶	Fuse (Amperes)	Switch (Amperes)
0.5	1.2	14	3	30	—	—	—	—	—	—	—	—
1	2.4	14	6	30	1.2	14	3	30	1.0	14	3	30
1.5	3.6	14	6	30	1.8	14	3	30	1.4	14	3	30
2	4.8	14	10	30	2.4	14	6	30	1.9	14	6	30
2.5	6.0	14	10	30	3.0	14	6	30	2.4	14	6	30
3	7.2	14	15	30	3.6	14	6	30	2.9	14	6	30
4	9.6	14	20	30	4.8	14	10	30	3.8	14	10	30
5	12	14	20	30	6.0	14	10	30	4.8	14	10	30
6	14	14	25	30	7.2	14	15	30	5.8	14	10	30
7.5	18	12	30	30	9.0	14	15	30	7.2	14	15	30
8	19	10	35	60	9.6	14	20	30	7.7	14	15	30
10	24	10	40	60	12	14	20	30	9.6	14	20	30
12.5	30	8	50	60	15	14	25	30	12	14	20	30
15	36	8	60	60	18	12	30	30	14	14	25	30
17.5	42	6	80	100	21	10	40	60	17	12	30	30
20	48	6	80	100	24	10	40	60	19	10	35	60
22.5	54	4	100	100	27	10	50	60	22	10	40	60
25	60	4	100	100	30	8	50	60	24	10	40	60
30	72	3	125	200	36	8	60	60	29	8	50	60
35	84	2	150	200	42	6	80	100	34	8	60	60
40	96	1	175	200	48	6	80	100	38	6	80	100
45	108	1/0	200	200	54	4	100	100	43	6	90	100
50	120	2/0	200	200	60	4	100	100	48	6	100	100
60	144	3/0	250	400	72	2	125	200	58	4	100	100
75	180	250M	300	400	90	1/0	150	200	72	3	125	200
80	192	300M	350	400	96	1/0	175	200	77	3	150	200
90	216	350M	400	400	108	1/0	200	200	86	1	150	200
100	241	400M	400	400	120	2/0	200	200	96	1	175	200
120	289	(2)3/0	500	600	144	3/0	200	200	115	2/0	200	200
125	300	(2)3/0	500	600	150	3/0	250	400	120	2/0	200	200
150	361	(2)250M	600	600	180	250M	300	400	144	3/0	250	400
180	432	(2)350M	750	800	216	350M	400	400	173	250M	300	400
200	481	(2)400M	800	800	241	400M	400	400	192	300M	350	400
240	—	—	—	—	289	(2)3/0	500	600	231	400M	400	400
250	—	—	—	—	300	(2)4/0	500	600	241	400M	400	400
300	—	—	—	—	361	(2)250M	600	600	289	(2)3/0	500	600
360	—	—	—	—	432	(2)350M	750	800	346	(2)250M	600	600
400	—	—	—	—	480	(2)500M	800	800	384	(2)300M	650	800

❶ 90°C Copper Type THHN, XHHW, or equivalent, applied at 75°C ampacity. Rate current based on operation at rated voltage, frequency, and kVAR. Consult National Electrical Code for other wire types. Above size based on 30°C ambient operation. (Refer to NEC Table 310.16.)

Note: Fuses furnished within capacitor assembly may be rated at higher value than shown in this table. The table is correct for field installations and reflects the manufacturer's suggested rating for overcurrent protection and disconnect means in compliance with the National Electrical Code.

Where should I install capacitors in my plant distribution system?

At the load

Because capacitors act as kVAR generators, the most efficient place to install them is directly at the motor, where kVAR is consumed. Three options exist for installing capacitors at the motor. Use **Figure 10** through **Figure 16** and the information below to determine which option is best for each motor.

Location A—motor side of overload relay

- New motor installations in which overloads can be sized in accordance with reduced current draw
- Existing motors when no overload change is required

Location B—line side of starter

- Existing motors when overload rating surpasses code

Location C—line side of starter

- Motors that are jogged, plugged, reversed
- Multi-speed motors
- Starters with open transition and starters that disconnect/reconnect capacitor during cycle
- Motors that start frequently
- Motor loads with high inertia, where disconnecting the motor with the capacitor can turn the motor into a self-excited generator

At the service feeder

When correcting entire plant loads, capacitor banks can be installed at the service entrance, if load conditions and transformer size permit. If the amount of correction is too large, some capacitors can be installed at individual motors or branch circuits.

When capacitors are connected to the bus, feeder, motor control center, or switchboard, a disconnect and overcurrent protection must be provided.

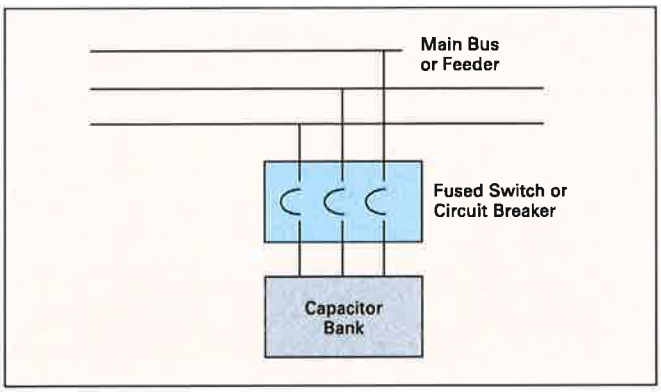


Figure 10. Installing Capacitors Online

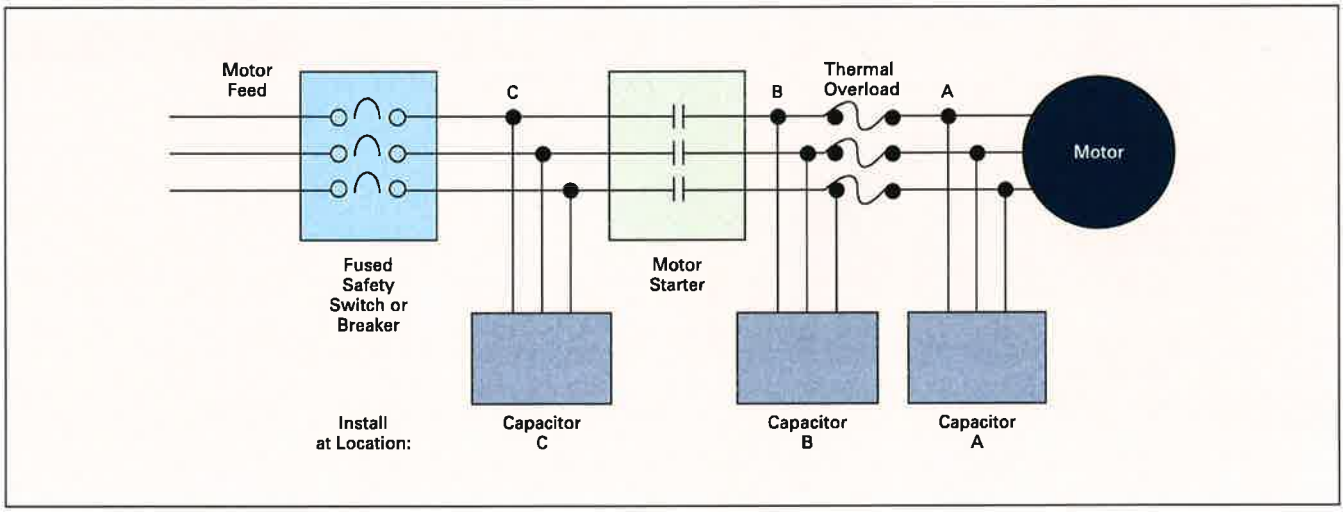


Figure 11. Locating Capacitors on Motor Circuits

Locating capacitors on reduced voltage and multi-speed motors

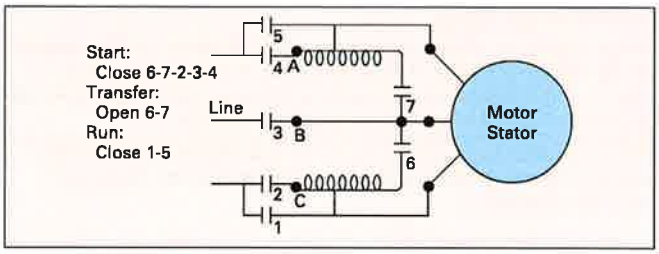


Figure 12. Autotransformer—Closed Transition

Note: Connect capacitor on motor side of starting contacts (2, 3, 4) at points A–B–C.

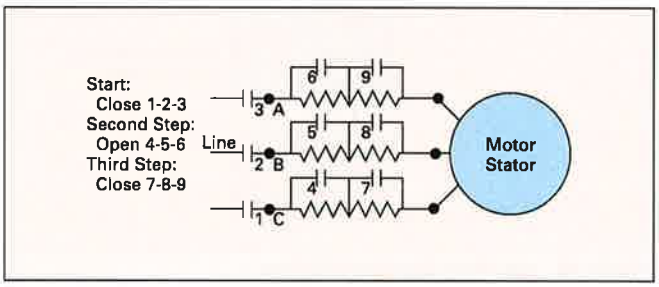


Figure 13. Series Resistance Starting

Note: Connect capacitor on motor side of starting contactor (1, 2, 3) at points A–B–C.

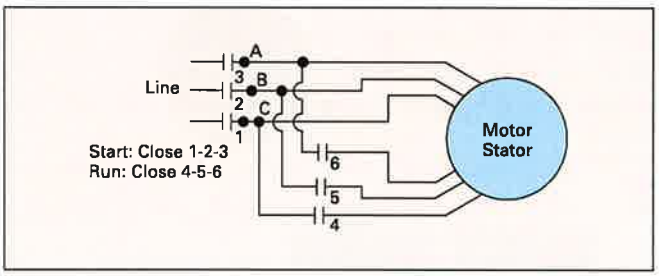


Figure 14. Part-Winding Starting

Note: Connect capacitor on motor side of starting contacts (1, 2, 3) at points A–B–C.

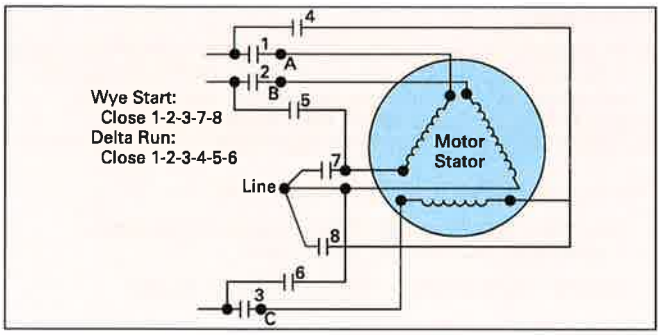


Figure 15. Wye-Delta Starting

Note: Connect capacitor on motor side of starting contacts (1, 2, 3) at points A–B–C.

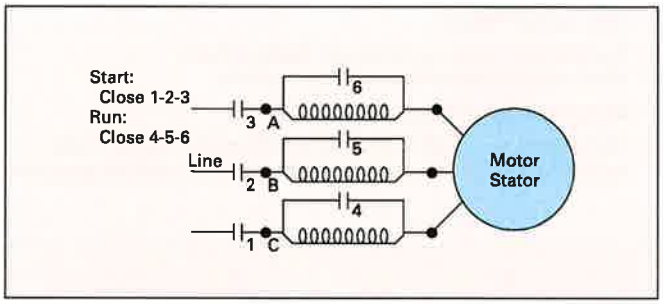


Figure 16. Reactor Starting

Note: Connect capacitor on motor side of starting contactor (1, 2, 3) at points A–B–C.

Can capacitors be used in nonlinear, nonsinusoidal environments?

Until recently, almost all loads were linear, with the current waveform closely matching sinusoidal voltage waveform and changing in proportion to the load. Lately, nonlinear loads—which draw current at frequencies other than 60 Hz—have increased dramatically.

Examples of linear and nonlinear devices are as follows:

Linear devices

- Motors
- Incandescent lighting
- Heating loads

Nonlinear devices

- DC drives
- Variable frequency drives
- Programmable controllers
- Induction furnaces
- Arc-type lighting
- Personal computers
- Uninterruptible power supplies (UPSs)

The increase in nonlinear loads has led to harmonic distortion in electrical distribution systems. *Although capacitors do not cause harmonics, they can aggravate existing conditions.*

Because harmonic voltages and currents are affected by all of the equipment in a facility, they are sometimes difficult to predict and model.

Capacitor banks and transformers can cause resonance

Capacitors and transformers can create dangerous resonance conditions when capacitor banks are installed at the service entrance. Under these conditions, harmonics produced by nonlinear devices can be amplified manyfold.

Problematic amplification of harmonics becomes more likely as more kVAR is added to a system that contains a significant amount of nonlinear load.

You can estimate the resonant harmonic by using this formula:

$$h = \sqrt{\frac{kVA_{sys}}{kVAR}}$$

kVA_{sys} = short-circuit capacity of the system
kVAR = amount of capacitor kVAR on the line
h = the harmonic number referred to a 60 Hz base

If h is near the values of the major harmonics generated by a nonlinear device—for example, 3, 5, 7, 11—then the resonance circuit will greatly increase harmonic distortion.

For example, if the plant has a 1500 kVA transformer with 5½% impedance, and the short-circuit rating of the utility is 48,000 kVA, then kVA_{sys} would equal 17,391 kVA.

If 350 kVAR of capacitors were used to improve power factor, h would be:

$$h = \sqrt{\frac{17{,}391}{350}} = \sqrt{49.7} = 7.0$$

Because h falls right on the 7th harmonic, these capacitors could create a harmful resonance condition if nonlinear devices were present in the factory. In this case, the capacitors should be applied only as harmonic filtering assemblies. For further information, see Harmonic Filter on **Page 22** of this document.

See **Page 19** (Part 2) for an additional discussion on harmonics.

What about maintenance?

Capacitors have no moving parts to wear out and require very little maintenance. Check fuses on a regular basis. If high voltages, harmonics, switching surges, or vibration exists, fuses should be checked more frequently.

Capacitors from Eaton operate warm to the touch. If the case is cold, check for blown fuses, open switches, or other power losses. Also check for bulging cases and puffed-up covers, which signal operation of the capacitor interrupter.

Code requirements for capacitors

Nameplate kVAR: Tolerance +15, –0%.

Discharge resistors: Capacitors rated at 600V and less must reduce the charge to less than 50V within 1 minute of de-energization. Capacitors rated above 600V must reduce the charge within 5 minutes.

Continuous operation: Up to 135% rated (nameplate) kVAR, including the effects of 110% rated voltage (121% kVAR), 15% capacitance tolerance, and harmonic voltages over the fundamental frequency (60 Hz).

Dielectric strength test: Twice the rated AC voltage (or a DC voltage 4.3 times the AC rating for non-metalized systems).

Overcurrent protection: Fusing between 1.65 and 2.5 times rated current to protect case from rupture. Does not preclude NEC requirement for overcurrent protection in all three ungrounded conductors.

Note: When capacitor is connected to the load side of the motor overcurrent protection, fused disconnects or breaker protection is not required. However, Eaton highly recommends fusing for all indoor applications whenever employees may be working nearby.

Useful capacitor formulas

Nomenclature:

C = Capacitance in µF
V = Voltage
A = Current
k = 1000

Additional data

Simplified voltage rise:

$$\% \text{ V.R.} = \frac{\text{kVAR (cap.)} \times \% \text{ transformer reactance}}{\text{kVA (transformer)}}$$

Losses reduction:

$$\% \text{ L.R.} = 100 - 100\left(\frac{\text{original PF}}{\text{improved PF}}\right)^2$$

Operation at other than rated voltage and frequency:

Note: Use of voltages and frequencies above the rated values can be dangerous. Consult the factory for any unusual operating conditions.

Reduced voltage:

$$\text{Actual kVAR (output)} = \text{Rated kVAR}\left(\frac{\text{actual voltage}}{\text{rated voltage}}\right)^2$$

Reduced frequency:

$$\text{Actual kVAR} = \text{Rated kVAR}\left(\frac{\text{actual frequency}}{\text{rated frequency}}\right)$$

Examples:

Voltage reduction:

$$\text{kVAR (208)} = \text{kVAR (240)}\left(\frac{208}{240}\right)^2 = 0.75$$

(10 kVAR @ 240V = 7.5 kvar @ 208V)

$$\text{kVAR (120)} = \text{kVAR (240)}\left(\frac{120}{240}\right)^2 = 0.25$$

(10 kVAR @ 240V = 2.5 kVAR @ 120V)

Frequency reduction:

$$\text{kVAR (50 Hz)} = \text{kVAR (60 Hz)}\left(\frac{50}{60}\right) = 0.83$$

(60 kVAR @ 480V, 60 Hz = 50 kVAR, 480V, 50 Hz)

Miscellaneous

$$\text{Power factor} = \cos\theta = \frac{\text{kW}}{\text{kVA}}$$

$$\tan\theta = \frac{\text{kVAR}}{\text{kW}}$$ (See **Table 6.**)

$$\text{Single-phase kW} = \frac{V \times A \times PF}{10^3}$$

$$\text{Three-phase kW} = \frac{\sqrt{3} \times V \times A \times PF}{10^3}$$

$$\text{Single-phase kVA} = \frac{V \times A}{10^3}$$

$$\text{Three-phase kVA} = \frac{\sqrt{3} \times V \times A}{10^3}$$

$$\text{Single-phase line current (A)} = \frac{\text{kVA} \times 10^3}{V}$$

$$\text{Three-phase line current (A)} = \frac{\text{kVA} \times 10^3}{\sqrt{3} \times V}$$

$$\text{Capacitor current (A)} = (2\pi f)\, CV \times 10^{-6}$$

$$\text{Single-phase capacitor current} = \frac{\text{kVAR} \times 10^3}{V}$$

$$\text{Three-phase capacitor current} = \frac{\text{kVAR} \times 10^3}{\sqrt{3} \times V}$$

$$\text{kVA} = \frac{\text{kW (kW motor input)}}{PF}$$

$$\text{(kW motor input)} = \frac{\text{hp} \times 0.746}{\text{efficiency}}$$

Approximate motor kVA = motor hp (at full load)

Table 8. Standard Data

		Amperes / kVAR	
Voltage	**µF / kVAR Total**	**Single-Phase**	**Three-Phase**
208	61.2	4.81	2.78
240	46.0	4.17	2.41
480	11.5	2.08	1.20
600	7.37	1.67	0.96
2400	0.46	—	0.24
4160	0.153	—	0.139

Note: Above is at nominal voltage @ 60 Hz = nominal kVAR µF and current.

Part two: harmonics

Introduction

There has been much discussion and interest in recent years on the subject of power quality. Whereas in the past, power received from the electric utility and used by an industrial plant was generally a pure sinusoidal waveform—for example, clean power—more frequently today, industrial plants are finding that they have to deal with the problem of "dirty" power. Dirty power is a slang expression used to describe a variety of voltage and current contaminations on the pure sinusoidal waveform. Dirty power can come in the form of short-term transients or steady-state, continuous distortions. In addition, the sources of dirty power can be external to a plant (as might be the case if a neighboring plant is contaminating the utility's distribution system), or the source can reside within the plant itself.

Harmonic distortion is a specific type of dirty power that is usually associated with an industrial plant's increased use of adjustable speed drives, power supplies, and other devices that use solid-state switching. However, harmonic distortion can be generated by any of a variety of nonlinear electrical devices existing within a manufacturing plant or within nearby plants. Because harmonic distortion can cause serious operating problems in certain plant environments, it is important that the plant engineer or facilities personnel understand the fundamentals of harmonic distortion, know how to recognize the symptoms of this problem, and know what can be done to solve the problems once they are identified.

What are harmonics?

A harmonic is a component of a periodic wave having a frequency that is an integral multiple of the fundamental power line frequency of 60 Hz. For example, 300 Hz (5 x 60 Hz) is a 5th order harmonic of the fundamental frequency (**Figure 17**). **Figure 18** shows the resultant wave when the fundamental and 5th harmonic are combined. The result is harmonic distortion of the power waveform.

Harmonics typically seen on a power system can be subdivided into two distinct categories by the nature of the problems they create and the remedies they usually require.

- Those harmonic currents that are the dominant harmonic orders created by three-phase nonlinear loads—5th, 7th, 11th, 13th, and higher order odd harmonics that are not multiples of three
- Those harmonics created primarily by single-phase nonlinear loads—3rd order harmonics and higher multiples of three. These are sometimes referred to as triplen or zero-sequence harmonics and are usually accompanied by some 5th, 7th, and other higher order harmonics

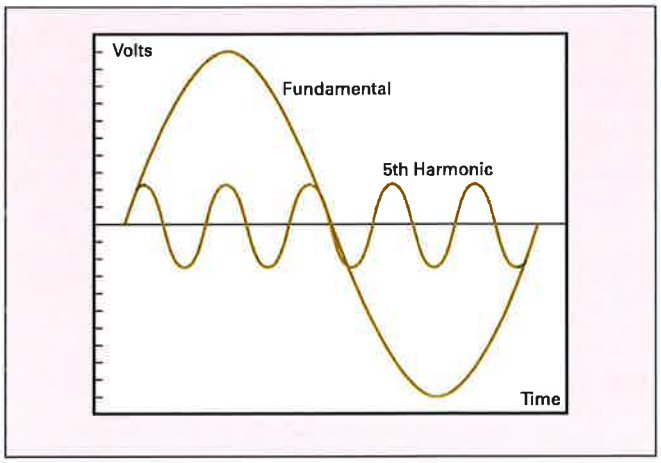


Figure 17. Fundamental and 5th Harmonic

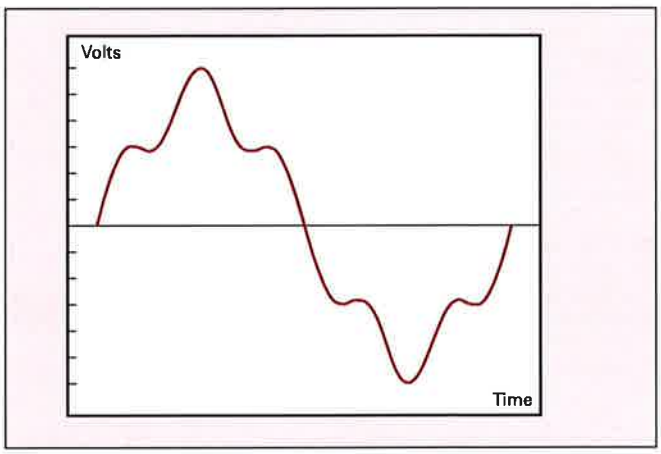


Figure 18. Fundamental and 5th Harmonic Combined

Harmonics are a steady-state phenomenon and should not be confused with short-term phenomena that last less than a few cycles. Transients, electrical disturbances, overvoltage surges, and undervoltage sags in the supplied voltage are not harmonics. Some of these short-term disturbances in voltage or current can be mitigated by transient voltage surge suppressors, line reactors, or isolation transformers. However, these devices usually have little, if any, effect on harmonic currents or voltages.

The level of voltage or current harmonic distortion existing at any one point on a power system can be expressed in terms of the total harmonic distortion (THD) of the current or voltage waveform. The THD (for a voltage waveform) is given by the following formula:

$$V_{thd} = \frac{\sqrt{V_2 + V_3 + \ldots + V_n}}{V_1}$$

where: V_1 = fundamental voltage value
V_n (n = 2, 3, 4, etc. ...) = harmonic voltage values

What are the consequences of high harmonic distortion levels?

Just as high blood pressure can create stress and serious problems in the human body, high levels of harmonic distortion can create stress and resultant problems for the utility's distribution system and the plant's distribution system, as well as all of the equipment that is serviced by that distribution system. The result may be the plant engineer's worst fear—the shutting down of important plant equipment ranging from a single machine to an entire line or process.

Equipment shutdown can be caused by a number of events. As an example, the higher voltage peaks that are created by harmonic distortion put extra stress on motor and wire insulation, which ultimately can result in insulation breakdown and failure. In addition, harmonics increase rms current, resulting in increased operating temperatures for many pieces of equipment, greatly reducing equipment life.

Table 9 summarizes some of the negative consequences that harmonics can have on typical equipment found in the plant environment. While these effects are categorized by problems created by current and voltage harmonics, current and voltage harmonic distortion usually exist together (current harmonic distortion causes voltage harmonic distortion).

Harmonic distortion disrupts plants. Of greatest importance is the loss of productivity, throughput, and, possibly, sales. These occur because of process shutdowns due to the unexpected failure of motors, drives, power supplies, or just the spurious tripping of breakers. Plant engineers realize how costly downtime can be and pride themselves in maintaining low levels of plant downtime. In addition, maintenance and repair budgets can be severely stretched. For example, every 10°C rise in the operating temperatures of motors or capacitors can cut equipment life by 50%.

Table 9. Negative Consequences of Harmonics on Plant Equipment

Equipment	Consequences
Current Harmonic Distortion Problems	
Capacitors	Blown fuses, reduced capacitor life
Motors	Reduced motor life, inability to fully load motor
Fuses/breakers	False/spurious operation, damaged components
Transformers	Increased copper losses, reduced capacity
Voltage Harmonic Distortion Problems	
Transformers	Increased noise, possible insulation failure
Motors	Mechanical fatigue
Electronic loads	Misoperation

IEEE 519

IEEE® Standard 519-1992, *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems,* represents the most recent effort to establish a standard level of acceptable harmonic distortion levels on a power system. **Table 10** and **Table 11** summarize the voltage and current harmonic distortion limits.

Note: The current distortion limits are dependent upon the size of the customer's load relative to the available short-circuit capacity of the utility (stiffness). In this way, customers whose loads potentially have more effect on the utility system and neighboring customers are held to the tighter limits.

Table 10. End User Limits—Current Distortion Limits for General Distribution Systems End-User Limits (120–69,000V) Maximum Harmonic Current Distortion in % of I_L Individual Harmonic Order (Odd Harmonics)

I_{sc}/IL	<11	11≤h<17	17≤h<23	23≤h<35	35≤h	TDD
<20 ❶	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

❶ All power generation equipment is limited to these values of current distortion, regardless of actual I_{sc}/IL.

Notes: Even harmonics are limited to 25% of the odd harmonic limits above. Current distortions that result in a direct current offset—for example, half wave converters—are not allowed.
Where I_{sc} = maximum short-circuit current at PCC
and I_L = maximum demand load current (fundamental frequency component) at PCC.

Table 11. Utility Limits—Voltage Distortion Limits

Bus Voltage at PCC	Individual Voltage Distortion (%)	Total Voltage Distortion THD (%)
69 kV and below	3.0	5.0
69.001 kV–161 kV	1.5	2.5
161 kV and above	1.0	1.5

Note: High voltage systems can have up to 2.0% THD where the cause is an HVDC terminal that will attenuate by the time it is tapped for a user.

Two very important points must be made in reference to the above limitations:

- The customer is responsible for maintaining a current distortion to within acceptable levels, while the utility is responsible for limiting voltage distortion
- The limits are only applicable at the point of common coupling (PCC) between the utility and the customer. The PCC, while not explicitly defined, is usually regarded as the point at which the utility equipment ownership meets the customer's, or the metering point. Therefore, the above limits cannot be meaningfully applied to, say, distribution panels or individual equipment within a plant—the entire plant must be considered when complying with these limits

Electric utilities are currently considering financial penalties and/or service interruption for customers injecting excessive harmonics into the utility system. Therefore, while a customer may not be currently penalized for low power factor, a harmonic distortion–based penalty structure, in the manner of IEEE 519, may be forthcoming.

How are harmonics generated?

Harmonics are generated by nonlinear loads. A nonlinear load is a circuit element that draws current in a nonsinusoidal manner. Until recently, most factory loads were primarily linear, with current waveform closely matching the sinusoidal voltage waveform and changing in proportion to the load. More recently, however, factory loads with major nonlinear components have increased dramatically. **Table 12** gives typical examples of linear and nonlinear devices.

Table 12. Examples of Linear and Nonlinear Devices

Primarily Linear Devices	Devices with Major Nonlinear Components
Some motors	DC drives
Incandescent lighting	Variable frequency drives
Heating loads	Programmable controllers
	Induction furnaces
	Solid-state uninterruptible power supplies (UPSs)
	Arc furnaces
	Arc welders

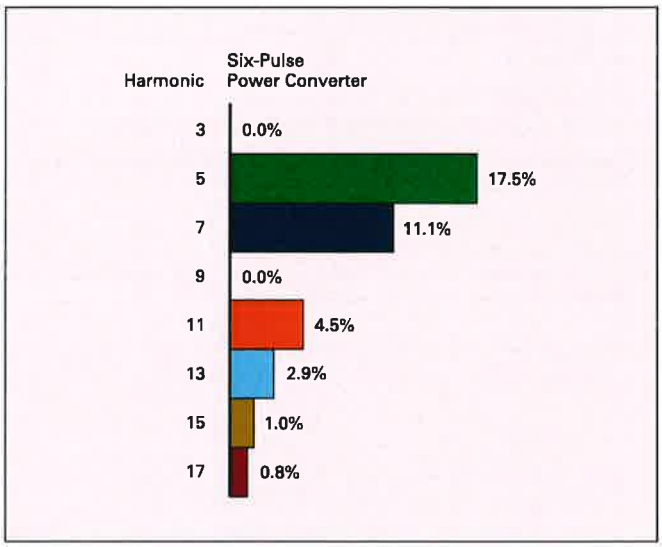


Figure 19. Harmonic Magnitude as Percentage of the Fundamental Current

Note: Harmonic currents typically injected by six-pulse VFDs.

Nonlinear devices that cause the most problems can generally be grouped into two categories—electronic power converters and arcing devices.

Electronic power converters

Electronic power converters—for example, adjustable speed drives and power supplies—are by far the largest contributors to harmonic distortion in today's plant environment. An electronic power converter changes electrical energy from one form to another, typically by rectifying the AC voltage into DC and utilizing the DC voltage directly or synthesizing a new AC voltage. This change is accomplished by using solid-state devices—silicon control rectifiers (SCRs), diodes, transistors—to periodically switch in the conducting circuits of the converter. **Figure 19** shows a typical harmonic current spectrum for a six-pulse electronic power converter. Below are some common names that are typically associated with electronic power converters.

Common names given to electronic power converters

- Adjustable speed drives
- Variable frequency drives
- SCR drives
- AC motor drives (AC/DC/AC)
- DC motor drives (AC/DC)
- Three-phase full wave rectifiers
- Three-phase full wave converters
- Six-pulse converters

As most plant engineers appreciate, there is an increased use of electronic drives due to their ability to more efficiently or precisely drive a motor or process.

Arcing devices

Arc furnaces and welders are the two types of arcing devices that cause the most harmonic distortion, although arc lighting (fluorescent, mercury vapor) will also cause small degrees of harmonic distortion.

Other equipment

Motors, generators, transformers, and arc lighting also have small nonlinear components, although the contribution of these devices to total harmonic distortion in a plant tends to be relatively small.

What do power factor correction capacitors have to do with harmonics?

A discussion of power system harmonics is incomplete without discussing the effects of power factor correction capacitors. In an industrial plant containing power factor correction capacitors, harmonic currents and voltages can be magnified considerably due to the interaction of the capacitors with the service transformer. This is referred to as *harmonic resonance* or *parallel resonance*. For a typical plant containing power factor correction capacitors, the resonant frequency (frequency at which amplification occurs) normally falls in the vicinity of the 5th to the 13th harmonic. Because nonlinear loads typically inject currents at the 5th, 7th, 11th, and 13th harmonics, a resonant or near-resonant condition will often result if drives and capacitors are installed on the same system, producing the symptoms and problems outlined in the previous section.

Note: Capacitors themselves do not cause harmonics, but only aggravate potential harmonic problems. Often, harmonic-related problems do not "show up" until capacitors are applied for power factor correction.

It is a common misconception that the problem of applying capacitors in harmonic environments is limited to problems caused for the capacitor itself—that the capacitor's lower impedance at higher frequencies causes a current overload into the capacitor and, therefore, must be removed. However, the capacitor/harmonics problem must be viewed from a power system standpoint. The capacitor-induced increase of harmonic voltages and currents on a plant's system may be causing problems while the capacitor itself remains within its acceptable current rating.

How do I diagnose a potential harmonics-related problem?

If a plant engineer suspects that he might have a harmonics problem, the following steps can easily be performed as an initial investigation into potential problems:

- Look for symptoms of harmonics as listed in **Table 9**. If one or more of these symptoms occurs with regularity, then the following steps should be taken
- If the plant contains power factor correction capacitors, the current into the capacitors should be measured using a "true rms" current meter. If this value is higher than the capacitor's rated current at the system voltage (by >5% or so), the presence of harmonic voltage distortion is likely
- Conduct a paper audit of the plant's harmonic-producing loads and system configuration. This analysis starts with the gathering of kVA or horsepower data on all the major nonlinear devices in the plant, all capacitors, and rating information on service entrance transformer(s). Eaton has specific analysis forms with instructions to guide the plant engineer in collecting this information, and engineers or sales representatives can provide assistance as needed. This data is analyzed by Eaton engineers to determine whether the conditions are present to create unfavorable levels of harmonics
- If the electrical distribution system is complex—for example, multiple service entrances, distributed capacitors—or if the paper audit is incomplete or considered to be too burdensome, the most definitive way to determine whether harmonics are causing a problem is through an on-site plant audit. This audit involves an inspection of the electrical system layout and connected loads, as well as harmonic measurements taken at strategic locations. This data can then be assembled and analyzed to obtain a clear and concise understanding of the power system. Eaton provides an engineering service to conduct these on-site plant audits

How can harmonics problems be eliminated?

When power factor correction is required in the presence of nonlinear loads, or the amount of harmonic distortion must be reduced to solve power quality problems or avoid penalties, the most reliable, lowest cost solution is often realized with the use of harmonic filters.

What is a passive harmonic filter?

A shunt harmonic filter (see **Figure 20**) is, essentially, a power factor correction capacitor combined with a series iron core reactor. A filter provides power factor correction at the fundamental frequency and becomes an inductance (like a motor) at frequencies higher than its turning point. Eaton harmonic filters are almost always tuned below the 5th harmonic. Therefore, the filter provides an inductive impedance path to those currents at harmonic frequencies created by nearly all three-phase nonlinear loads (5th, 7th, 11th, 13th, and so on). Since the filter is not capacitive at these frequencies, the plant electrical system can no longer resonate at these frequencies and cannot magnify the harmonic voltages and currents. A shunt harmonic filter therefore accomplishes three things:

- Provides power factor correction
- Prevents harmonic overvoltages due to parallel resonance
- Reduces voltage harmonic distortion and transformer harmonic loading at frequencies above its turning point

In some circumstances, a harmonic resonance condition may accrue gradually over time as capacitors and nonlinear loads are installed in a plant. In those instances, replacement of such capacitors with harmonic filters is in order to correct the problem.

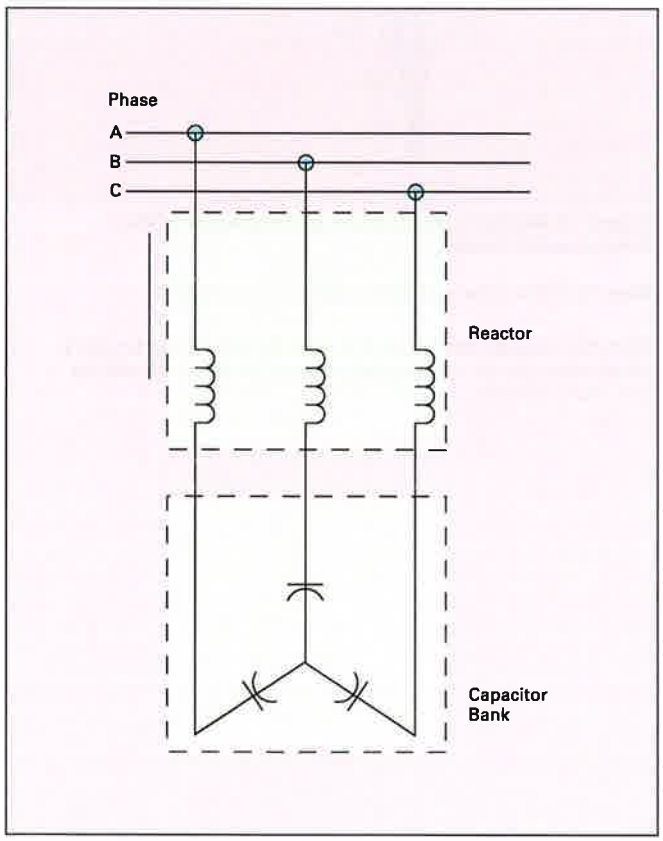


Figure 20. Shunt Harmonic Filter

Do I need to perform a system analysis to correctly apply harmonic filters?

The proper application of harmonic filters can be greatly simplified by recognizing that there are only a few pieces of pertinent information and analysis steps that need to be taken for most systems in order to correctly deal with the problem.

Eaton's approach to power system harmonic diagnosis and solutions has evolved, via years of accumulated knowledge and experience, to an approach that eliminates needless analytical complexity in the majority of circumstances. Rather, it relies on the relatively few pieces of information that are required to make the correct applications decision. If this information indicates that some type of metering and measurement is required, then only those select measurements that yield useful information will be performed, keeping the complexity and cost to a minimum without sacrificing solution correctness.

Our abilities in the area of harmonic analysis, however, extend to our state-of-the-art computerized analysis tools should the customer require the thoroughness afforded by such tools.

One of the most basic and useful pieces of information that *must* be known before attempting to correct power factor in the presence of nonlinear loads is the ratio of the total nonlinear kVA to the service transformer kVA rating. This ratio alone can often be used to determine whether harmonic filters are necessary to correct power factor or whether plain capacitors can be added without experiencing problems as follows:

- If the plant's total three-phase nonlinear load (in kVA, 1 hp = 1 kVA) is more than 25% of the main transformer capacity, harmonic filters will almost always be required for power factor correction
- If the plant's total three-phase nonlinear load is less than 15% of the main transformer capacity, capacitors can usually be applied without problems
- If the plant's total nonlinear load is between 15 and 25%, other factors should be considered

Starting with this most basic information, your Eaton sales representative will work with you to determine what additional information or measurement, if any, is required in order to recommend the correct solution to your problem.

What is Eaton's experience in harmonic filtering?

Eaton has been in the power capacitor business for 70 years, manufacturing power factor correction capacitors used in low voltage and medium voltage applications. In the 1980s, we began working with a number of customers to help resolve problems related to harmonic distortion. During that time, we developed a number of designs to incorporate harmonic filtering in both fixed and automatic capacitor banks. The success of these installations has made Eaton the leader in the field of harmonic filters.

With a fully integrated manufacturing process, we maintain the strictest quality control systems in the industry. All power capacitors are 100% tested at various stages in their manufacture and prior to shipment to ensure a long service life. In addition, Eaton provides on-site supervision and startup assistance to ensure that all capacitor and harmonic filtering assemblies are properly applied in the plant environment.

Please call **1-800-809-2772** for assistance in understanding and solving any problems that you have involving capacitors or harmonics in your facility.

Eaton is dedicated to ensuring that reliable, efficient and safe power is available when it's needed most. With unparalleled knowledge of electrical power management across industries, experts at Eaton deliver customized, integrated solutions to solve our customers' most critical challenges.

Our focus is on delivering the right solution for the application. But, decision makers demand more than just innovative products. They turn to Eaton for an unwavering commitment to personal support that makes customer success a top priority. For more information, **visit www.eaton.com/electrical**.

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- ✓ Before you **buy ceiling fan online**, you need to understand its specifications. These include sweep, power input, and air delivery. The larger the size of the fan blades, the greater the sweep.
- ✓ The power input measured in watts decides the power consumption of the fan. The higher the power input, the higher the power consumption.
- ✓ The air delivery is measured in CMM or cubic meters per minute. The higher the CMM, the higher the air delivery.

Source: CROMPTON

AN OVERVIEW OF GREENHOUSE GAS EMISSIONS

Gases that trap heat in the atmosphere are called greenhouse gases. This section provides information on emissions and removals of the main greenhouse gases to and from the atmosphere.

Carbon dioxide (CO_2): Carbon dioxide enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and other biological materials, and also as a result of certain chemical reactions (e.g., manufacture of cement). Carbon dioxide is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.

- **Methane (CH_4)**: Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices, land use and by the decay of organic waste in municipal solid waste landfills.
- **Nitrous oxide (N_2O)**: Nitrous oxide is emitted during agricultural, land use, industrial activities, combustion of fossil fuels and solid waste, as well as during treatment of wastewater.
- **Fluorinated gases**: Hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for stratospheric ozone-depleting substances (e.g., chlorofluorocarbons, hydrochlorofluorocarbons, and halons). These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases ("High GWP gases").

Each gas's effect on climate change depends on three main factors:

How much is in the atmosphere?

Concentration, or abundance, is the amount of a particular gas in the air. Larger emissions of greenhouse gases lead to higher concentrations in the atmosphere. Greenhouse gas concentrations are measured in parts per million, parts per billion, and even parts per trillion. One part per million is equivalent to one drop of water diluted into about 13 gallons of liquid (roughly the fuel tank of a compact car).

How long do they stay in the atmosphere?

Each of these gases can remain in the atmosphere for different amounts of time, ranging from a few years to thousands of years. All of these gases remain in the atmosphere long enough to become well mixed, meaning that the amount that is measured in the atmosphere is roughly the same all over the world, regardless of the source of the emissions.

How strongly do they impact the atmosphere?

Some gases are more effective than others at making the planet warmer and "thickening the Earth's blanket."

For each greenhouse gas, a Global Warming Potential (GWP) has been calculated to reflect how long it remains in the atmosphere, on average, and how strongly it absorbs energy. Gases with a higher GWP absorb more energy, per pound, than gases with a lower GWP, and thus contribute more to warming Earth.

Greenhouse gases trap heat and make the planet warmer. Human activities are responsible for almost all of the increase in greenhouse gases in the atmosphere over the last 150 years.[1] The largest source of greenhouse gas emissions from human activities in the United States is from burning fossil fuels for electricity, heat, and transportation.

EPA tracks total U.S. emissions by publishing the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*. This annual report estimates the total national greenhouse gas emissions and removals associated with human activities across the United States.

The primary sources of greenhouse gas emissions in the United States are:

- Transportation (29 percent of 2019 greenhouse gas emissions) – The transportation sector generates the largest share of greenhouse gas emissions. Greenhouse gas emissions from transportation primarily come from burning fossil fuel for our cars, trucks, ships, trains, and planes. Over 90 percent of the fuel used for transportation is petroleum based, which includes primarily gasoline and diesel.[2]
- Electricity production (25 percent of 2019 greenhouse gas emissions) – Electricity production generates the second largest share of greenhouse gas emissions. Approximately 62 percent of our electricity comes from burning fossil fuels, mostly coal and natural gas.[3]

- Industry (23 percent of 2019 greenhouse gas emissions) – Greenhouse gas emissions from industry primarily come from burning fossil fuels for energy, as well as greenhouse gas emissions from certain chemical reactions necessary to produce goods from raw materials.
- Commercial and Residential (13 percent of 2019 greenhouse gas emissions) – Greenhouse gas emissions from businesses and homes arise primarily from fossil fuels burned for heat, the use of certain products that contain greenhouse gases, and the handling of waste.
- Agriculture (10 percent of 2019 greenhouse gas emissions) – Greenhouse gas emissions from agriculture come from livestock such as cows, agricultural soils, and rice production.
- Land Use and Forestry (12 percent of 2019 greenhouse gas emissions) – Land areas can act as a sink (absorbing CO_2 from the atmosphere) or a source of greenhouse gas emissions. In the United States, since 1990, managed forests and other lands are a net sink, i.e., they have absorbed more CO_2 from the atmosphere than they emit.

Source : USENVIRONMENT PROTECTION AGENCY (USEPA)

https://www.epa.gov/ghgemissions/overview-greenhouse-gases

AN ESTIMATE OF GHG EMISSIONS IN INDIA - Source: CSTEP & GHGPLATFORM INDIA

The public electricity generation sector contributes to 68.3% of the emissions from the energy sector, followed by transport (17.9%), other sectors (11.1%), and fugitive emissions (2.6%) in 2015. Road sector emissions are the highest within the transport sector. In case of residential and commercial sectors, DG sets contribute to the highest emissions.

Table 3.2.B: State-wise emissions estimates ($MtCO_2e$) per capita (2005 - 2015)

State	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Andaman & Nicobar	1.00	1.16	1.31	1.05	1.21	1.35	1.42	1.50	1.77	1.90	1.94
Andhra Pradesh[3]	0.97	1.02	1.09	1.16	1.23	1.31	1.39	1.46	1.49	1.46	1.50
Arunachal Pradesh	0.27	0.28	0.29	0.30	0.33	0.34	0.34	0.34	0.36	0.36	0.37
Assam	0.26	0.27	0.27	0.28	0.28	0.29	0.30	0.29	0.30	0.32	0.33
Bihar	0.17	0.17	0.17	0.21	0.25	0.28	0.29	0.29	0.30	0.32	0.35
Chandigarh	0.57	0.59	0.60	0.63	0.66	0.69	0.69	0.66	0.64	0.66	0.74
Chhattisgarh	1.59	1.65	1.77	2.29	2.72	2.98	3.15	3.38	3.44	3.70	3.90
Dadra & Nagar Haveli	0.92	0.86	0.80	0.76	0.76	0.77	0.76	0.79	0.90	1.07	1.29
Daman & Diu	1.36	1.22	1.12	1.08	1.13	1.16	1.24	1.45	1.66	1.70	1.70
Delhi	1.80	1.45	1.49	1.45	1.36	1.31	1.37	1.39	1.28	1.22	1.15
Goa	1.13	1.26	1.37	1.40	1.42	1.44	1.48	1.46	1.47	1.55	1.60
Gujarat	1.03	1.04	1.13	1.12	1.12	1.20	1.34	1.51	1.57	1.68	1.68
Haryana	0.91	1.03	1.09	1.19	1.34	1.45	1.59	1.73	1.78	1.84	1.67
Himachal Pradesh	0.27	0.28	0.30	0.30	0.31	0.32	0.33	0.35	0.35	0.36	0.38
Jammu & Kashmir	0.23	0.24	0.25	0.25	0.25	0.26	0.28	0.29	0.30	0.31	0.32
Jharkhand	0.78	0.82	0.85	0.85	0.88	0.87	0.91	0.99	1.02	0.92	0.95
Karnataka	0.46	0.51	0.53	0.55	0.62	0.65	0.70	0.77	0.84	0.87	0.88
Kerala	0.28	0.30	0.32	0.35	0.38	0.39	0.41	0.42	0.45	0.47	0.47
Lakshadweep	0.60	0.70	0.92	1.07	1.13	1.16	5.53	11.47	4.38	1.62	1.72
Madhya Pradesh	0.79	0.81	0.89	0.95	0.95	0.96	0.98	0.97	1.00	1.15	1.36
Maharashtra	1.01	1.03	1.10	1.14	1.15	1.16	1.20	1.23	1.26	1.33	1.40
Manipur	0.15	0.15	0.15	0.16	0.17	0.15	0.16	0.20	0.23	0.26	0.27
Meghalaya	0.36	0.36	0.37	0.38	0.39	0.42	0.46	0.46	0.47	0.43	0.40
Mizoram	0.23	0.23	0.23	0.24	0.25	0.26	0.27	0.28	0.28	0.28	0.28
Nagaland	0.20	0.19	0.19	0.20	0.19	0.19	0.20	0.20	0.20	0.20	0.20
Orissa	1.11	1.21	1.27	1.25	1.27	1.26	1.36	1.43	1.50	1.59	1.70
Pondicherry	1.02	1.14	1.15	1.12	1.18	1.19	1.13	1.05	1.05	1.00	1.10
Punjab	1.00	1.03	1.11	1.17	1.25	1.20	1.16	1.12	1.08	1.12	1.14
Rajasthan	0.55	0.57	0.58	0.60	0.62	0.67	0.71	0.75	0.78	0.90	0.91
Sikkim	0.31	0.29	0.28	0.30	0.35	0.41	0.41	0.39	0.41	0.41	0.43
Tamil Nadu	0.97	1.01	1.07	1.07	1.16	1.17	1.15	1.16	1.16	1.24	1.27
Tripura	0.52	0.55	0.54	0.54	0.56	0.58	0.66	0.74	0.65	0.69	0.80
Uttar Pradesh	0.57	0.60	0.63	0.65	0.65	0.67	0.70	0.73	0.77	0.78	0.77
Uttarakhand	0.22	0.24	0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.37

[3] The analysis considers emissions from undivided Andhra Pradesh

NOTE ON PRAGATI RESORTS

When Pragati was established in 1994, the area was totally barren with terrible climate conditions such that even lizards would not lay eggs there. The water in the location was completely depleted due to mining of lime stone (suddha) which made the land unfit for cultivation. Dr G.B.K Rao CMD Pragati Group selected this land on the basis of three criteria – it is away from the city and highway, non-cultivable /barren land and totally depleted of water. Now, this area has been turned into a location people call "Pragati is Heaven on Earth."

Pragati Green Meadows And Resorts Ltd is ISO 9001:2015, ISO 14001:2015 , ISO 45001:2018, Organic & IGBC rated Resorts. Pragati is one of World's First Resort to obtain integrated ISO certification and Green rating from Indian Green Building Council (IGBC).

Dr. G.B.K. Rao, the Chairman and Managing Director of Pragati believes that the only answer to the two potential threats – 'Hunger' and 'Pollution' is "Vruksho Rakshati Rakshitaha & Gow Samrakshana", started his journey to create what is today Pragati Bio-diversity Knowledge Park a globally renowned man made biodiversity park. His passion and love for nature & its ecological balance has only grown since then. Pragati Bio-diversity Knowledge Park promoted by Pragati Green Meadows and Resorts Ltd realizes the concept of self-sustainable Green Living spaces.

Pragati Group's trailblazing legacy of two decades can be retraced to its profound reverence for safeguarding the purity of the Pancha bhootas, the five elements of Indian ethos- air, water, fire, earth and sky. And their deep rooted belief for upholding the principles of 'Vruksho Rakshati Rakshitaha' and 'Gow Samrakshana,' viz., the significance of the cattle and the ecology as depicted in all the images of Lord Sri Krishna, which is the basis of leading a holistic life, full of contentment and prosperity.

Dr G.B.K Rao, an industrialist-turned-environmentalist, strongly believes that Indian culture is an inalienable part of nature, and only when sacred herbal and medicinal plants and sacred desi cows are protected, nature is protected, and man can lead a happy and healthy life. 800

varieties of such sacred herbal heritage medicinal plants, other rare Mother plants and trees which are Kalpavrukshalu are our age-old Prana Pradatas and Arogya Pradatas have been arranged into sacred vanams. The sacred vanams Navagraha Vanam, Nakshatra Vanam, Rasi Vanam, Panchbhoota Vanam, Parijata Vanam, Kadamba Vanam, Sugandha Vanam, Ganapathi 21 Patrika Vanam etc get the desired impact as enshrined in our Vedas. These healing herbs remove toxins and refresh an individual through aroma therapy. They have thereby enabled to make the area completely free from mosquitoes, bad bacteria and viruses.

ENVIROSAFE

A Report on Green Audit

Bhavan's Vivekananda College

of Science, Humanities and Commerce

Sainikpuri, Hyderabad

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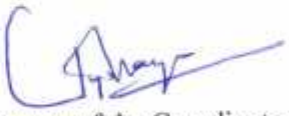
Acknowledgement

The green audit team would like to thank the Management of Bhavan's Vivekananda College of Science, Humanities and Commerce, Sainikpuri, Hyderabad for assigning this work. We would also like to thank for the cooperation extended by the Principal (Prof. Y. Ashok) in smooth conduct of this audit. The team also thanks the heads of the various departments for their valuable inputs during the audit. We also thank all the staff members and students for their active participation and involvement in gathering and compiling the data. We Mr. Chepuri Sridhar Rao S.F.S District Forest Officer Siddipet, Telangana for giving his valuable time and inputs to carry the green audit.



Signature of the Coordinator

Executive summary

Energy management:
The college is equipped with a solar power plant grid which is placed on the roof top of IT block,it bears a capacity of 30 KW. This grid is capable of generating 43,800 units of electricity on an average per year. This serves as a model for non-conventional use of energy. Care is taken at every level for optimum utilization of resources on the campus in terms of purchase of equipment with star rating.

Waste management:
The general waste management strategy adopted by college is proper segregation of waste where part of biodegradable component is subjected to vermi-composting and organic farming. However, no special strategies are followed for managing inorganic wastes like plastics. Since the generation of biodegradable waste is more in campus, proper composting mechanisms need to be adopted and the campus should be declared free from plastic which should be followed strictly. Proper measures also need to be adopted for effective liquid waste and E-waste managements.

Water management:
The college follows efficient water conservation mechanisms which is observed in terms of 22 rain water harvesting pits spread in different areas of campus. Almost every block has a rain water harvesting pit which is observed as healthy practice. The quality of drinking water is tested at regular intervals for coliform count by Department of Microbiology. This is to ensure proper maintenance and functioning of aquaguard systems. However, drip irrigation for gardening to achieve “more crop per drop” to be introduced as it has vast green carpet area. The college also need to work on “water foot print” to quantify consumption of water through meter system

Green area:
The lush green campus is an asset to college with 63 different plant species which shows high biodiversity. The campus is rich with various medicinal and ornamental plants. High carbon sequestration value indicates good quality of air in campus. Total campus area is uniformly distributed with green plantations. Tree plantation every year, as a part of “Haritha Haram” program is a healthy practice adopted by college. Different awareness programs organized as a part of “greENERGY” club strengthens the green concepts and environmental consciousness adopted by college.

Transportation:
Transportation to college by public means of transport/bicycles/walk accounts to only 33.26 %,this adds up carbon foot print to environment. More awareness programs on vehicle pooling and other public transport methods needs to be created among the students and staff.

Envirosafe - Report

1. Introduction

Recent developments in technology have exploited the natural resources that resulted in changes in environment. Man made threats to the Earth's natural environment includes pollution, deforestation, industrialization and various other disasters. All these activities have resulted in extinction of many flora and fauna.

At this juncture, it is the responsibility of each individual to psychologically construct environmental consciousness that includes environment related knowledge, awareness, concerns, responsibility and values. A better measure of environmental responsibility is to inculcate the habit of following the principles of 3R's-Reduce, Reuse and Recycle, to create a sustainable future. Sustainability implies a balance in exploitation of resources, orientation of technological development and institutional role to enhance both current and future potential to meet human needs by implementing long term plans.

Green audit therefore is a "systematic identification, quantification, recording, reporting and analysis of components of environmental diversity".

About the college

Kulapathi Dr. K. M. Munshi founded BharatiyaVidyaBhavan on 7th November, 1938 with the blessings of Mahatma Gandhi. Over a period of time, the Bhavan has grown into a secular, apolitical, cultural and educational organization. It has around 367 constituent institutions, 119 centers in India and 8 centers overseas. About 22,000 members have committed themselves to the Bhavan's ideal "VasudhaivaKutumbakam" (The World is One Family) and lives by its code.

Bhavan's Vivekananda College of Science, Humanities and Commercewas established in 1993 under the aegis of the BharatiyaVidyaBhavan, Mumbai. The sprawling 10 acres verdant campus has a peaceful atmosphere essential for academic pursuits. The campus is located at an accessible distance of 8 km from Secunderabad station and 2.5km from Ramakrishnapuram railway station.Thecollege provides excellent infrastructure, with the backing of supportive management, dedicated principal, a team of well qualified and experienced faculty and committed support staff. The college is able to provide a holistic education for its students and mold them to be productive citizens.

Bhavan's Vivekananda College of Science, Humanities and Commerce a reputed academic institute has the ability and responsibility to positively enhance the students' lives to meet their future needs. This section provides a comprehensive picture of how the college has integrated environment consciousness and sustainability in different forms like energy conservation, green

campus, reduce the generation of non-biodegradable wastes and create awareness. The environmental issues are taken seriously and have invested its effort to create awareness and sustain its campus a holistic and healthy place for good education and excellence in an eco-friendly way.

2. Objectives of the study

The objectives of the study are to assess the performance and activities in conservation of energy, methodologies used for it and to monitor their implementation. The purpose was to promote projects for environment protection and sustainability and use the data of green audit as a guidance tool

- To implement energy conservation strategies for a sustainable environment.
- To standardize appropriate methods for waste management
- Optimum utilization of resources available in the campus.
- To minimize pollution by adopting “go green” concept and create awareness on eco-friendly methods.

3. Methodology

A three-pronged approach was followed for green audit i.e., measure, monitor and control. Methods adopted for green auditincludes conducting a survey, physical inspection of the campus, collection and documentation of the data, analysis of data, suggestions and recommendations. The area of the audit covers the following:

- Energy Conservation
- Waste Management
- Water Management
- Green area Management
- Awareness programs

4. Observations and findings

The college has initiated various steps to promote Energy Efficient Green practices and use of renewable energy. Following are the measures taken by the institution.

4.1 Energy conservation

It addresses energy consumption, energy sources, energy monitoring, lighting, mode of transport. The college has taken various initiatives to promote Energy efficient practices and use of renewable energy,

- The college has an energy demand of 85KW of which 35.29% is offset by renewable energy, by installation of a roof surface using grid connected to roof top solar system. We are proud to claim that we are able to contribute to National Solar Mission. [Annexure –I]

- The campus utilizes energy efficient LED bulbs and florescent tubes. The college strictly follows the policy of “switch- off” the electrical items when not in use. Appropriate usage of resources and control is well managed by staff and students to avoid wastage. All the science departments takeresponsibility for their lab electrical equipment’s maintenance and utility.

- The construction and position of all the classrooms in each building is conducive for maximum natural light in the campus. It supports the minimum use of lights during day time. The arrangement of windows/ doors to wall ratio in classrooms allows natural ventilation and skylight. Ventilators near the upper roof surface allow easy movement and circulation of fresh air. The lighting arrangements are well planned to switch ON and OFF independently, so over lit areas are not observed.

- The use of Air conditioners in the campus is minimum. Care was taken to purchase air conditioners with more than three-star ratingsexcept one which is two stars. They are used only when there is a need to avoid unnecessary heat liberation and all the doors, windows are closed when it is in use. Science departments of the college are equipped with refrigerators to store the samples at low temperatures. Majority of them are either three or four star rated products [Annexure II]

- The college has procured a generator which has a minimum use, only when there is a shutdown of the power supply due to unavoidable circumstances.

- The nearest RTC bus-stop is about 0.5 km from the college, and the local railway station is 3 km away. Students and employees who live in the neighborhood come to the college either by walk or on bicycle. Several students and staff live at distant places and they commute daily by public transport or motorcycles / cars. A recent survey conducted to quantify the use of different modes of commuting has revealed that 0.57% of the students and staff use bicycles, 4.57% walk to college, 28.11% use public transport. It is presumed that the rest commute by motorbikes or cars. [Annexure –III]

4.2 Waste management

4.2.1 Solid waste management

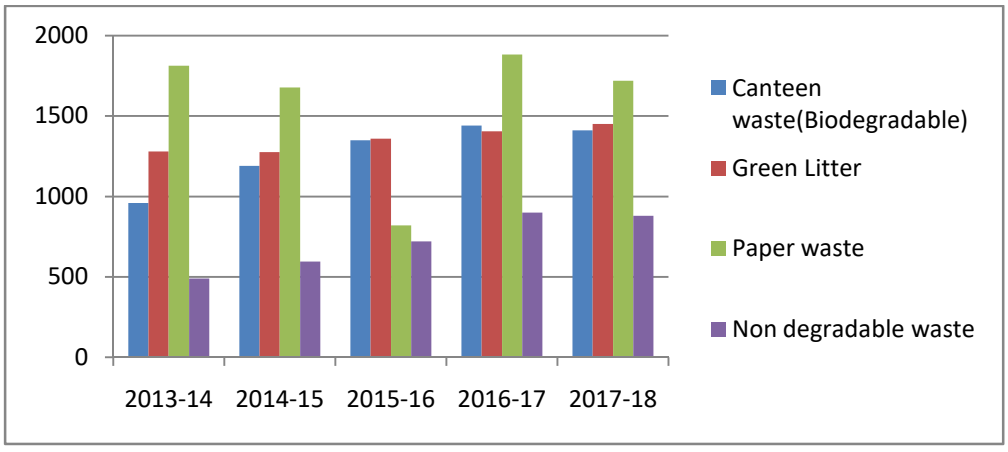
- Anything that is used,overused or unwanted is treated as waste. To maintain a sustainable environment, waste generated cannot be disposed in their prevailing condition. Waste need to be segregated and disposed properly. It also requires a proper disposal mechanism. Techniques for waste management differ from location to location depending on the availability of resources in that particular area. The waste that is generated should be segregated into biodegradable and non-biodegradable waste. Care must be taken to recycle and reuse the non-biodegradable waste instead of dumping into the environment which poses more health problems to living beings in that area.

- Keeping in view of the importance of waste management the college has taken up initiative to effectively manage the waste with the following objectives:

  i. To identify the source of waste generation
  ii. To create awareness and educate on importance of waste management
  iii. Segregate the waste into biodegradable and non-biodegradable waste
  iv. Identify proper disposal methods.
  v. Measures to reduce the generation of waste

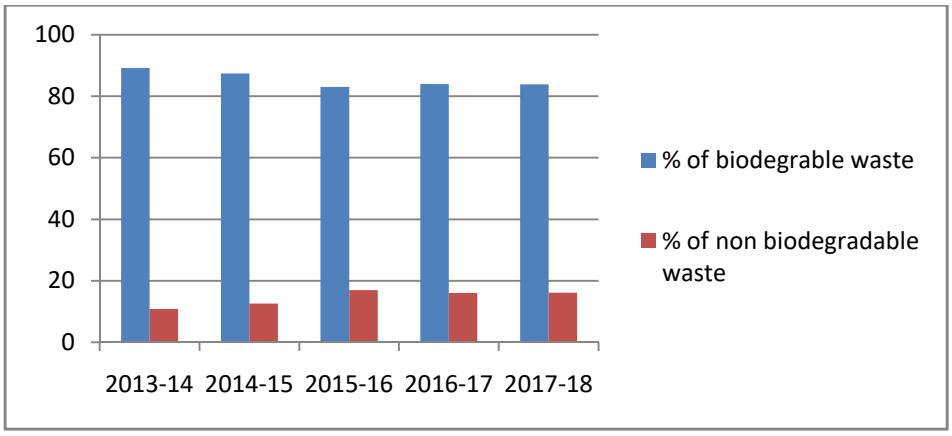
- A preliminary survey was conducted by green audit team with student volunteers to note the sources of waste generation in the campus. The waste was categorized into solid, liquid and e-waste respectively. The major sources of solid waste generation in the campus was recorded as canteen waste, green litter, used paper, plastic etc. Liquid waste was observed mainly at canteen, laboratories and wash rooms. The main source of E waste is observed at computer and other electronic labs.

Types of waste generated on the campus (kg/annum)



- The waste that is generated in the college campus was segregated into biodegradable and non-biodegradable waste at the respective places. Separate bins were placed at different locations in the campus adjacently with color code and proper labelling for a clear and marked distinction of waste.

- Most of the waste generated in the campus is biodegradable waste comprising mostly of green droppings, vegetable waste from canteen, papers etc. College has taken up initiative of doing trash audit since 2013. Amount of biodegradable waste was quantified at regular intervals. Some of the properly screened vegetable waste and green droppings goes to vermicomposting pit for further degradation and all types of used paper goes for recycling to ITC.



- The non-biodegradable waste generated in the campus is sent to GHMC disposal for further recycling process. Increase in percentage of nonbiodegradable waste correlates with increase in strength of college in terms of number of students, teaching and nonteaching faculty. However, initiatives were taken to bring down the quantum of non-biodegradable waste in college like replacing thermocol plates and bowls in canteen with paper plates and steel plates, minimizing the use of plastic etc.

- Metal and wood waste generated goes for proper disposal through authorized scrap agents.

- Most of the office correspondence, records and filing have been computerized, reducing paper usage. As an initiative to reduce the use of paper in the examinations, CIA tests for post graduate students are conducted on-line. The CGPC (Career Guidance and Placement Cell) of the college conducts Placement Eligibility Tests (PET exam) for the final year students online. Messages related to important meetings, dates, unexpected holidays, and any other related information are sent to all the members of the college through bulk SMS, and WhatsApp. The college website is updated with the latest information pertaining to academics, examinations, seminars, workshops, field trips,

competitions; activity reportsand photo gallery are available on the website.Bulk SMSand emails are used for official communication. The scholarship payments, salaries of the employees are disbursed through HDFC Bank, Kapra branch, Hyderabad.

Recycling of used papers

- As an awareness program and to recycle the paper, the greEnergy club of our college has a MOU with ITC limited to hand over the used papers, newspapers and magazines for recycling that are collected from various departments, and office.[Annexure IV]

4.2.2 Liquid waste management

The source of generation of liquid waste are:

1. Canteen area through washings-the liquid waste generated is connected to drain system which percolates into nearby garden.

2. Waste water from chemistry lab through lab washings is disposed of properly by standardized protocols.Acid or base liquid wastes generated in laboratories are neutralized and disposed in allocated area.

3. Standard protocols were followed in each laboratory for proper disposal of waste.

4.2.3 E Waste management

- Total no. of computers in the college is 343 out of which 319 are used for academic purpose and 24 for administrative purpose (264 in computer labs, 43 in various departments, 15 in library, 9 in examination branch and 12 in office).

- UPS utilized in the college are well monitored and care is taken in improving its efficiency, the life span of batteries may be upto 3 years or more depending on its usage. If the capacity is found reduced they are stored in a safe place and returned to the same dealer who has supplied with a concept of “BUY BACK OLD BATTERY”.

- The cartridges of laser printers are refilled outside the college campus.

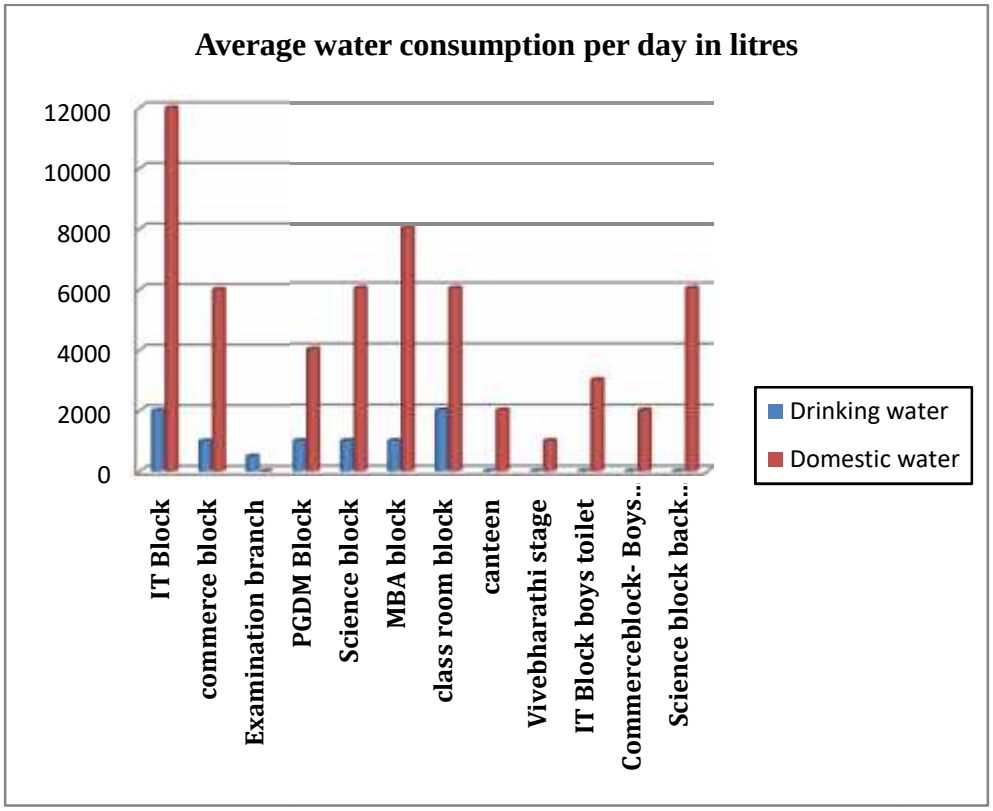
- The worn out, non-functioning components of the computer related items are stored and guarded safely before its disposal.On the recommendation of the computer science department and with the approval of the Principal, these computers and other parts of the computer like mother boards, keyboards and cables are written off and disposed to authorized vendors.

Measures under consideration to reduce waste generation:

1. Replacement of paper plates with stainless steel to reduce generation of waste in canteen.
2. Organic composting to be done on a large scale
3. Procurement of automatic composting machines to bring down the total biodegradable waste generated to zero percent. The generated manure can be used for organic farming in the college premises.
4. Effective E-waste disposal/recycling methods need to be standardized.

4.3. Water Management

- Two sources of water are available in the campus they include fresh Manjeera drinking water from municipal water supply and borewell water. The college makes use of both sources of water.The total water consumption per day including fresh water and bore water accounts to around 64,500 litres/day for 3800 people. On an average the water consumption is estimated to be approximately 17 litres per individual which includes both drinking water and domestic water.
- Proper care is taken regarding maintenance to ensure there is no leakage from taps, pipes and valves. Random checks were done regularly.
- Push button taps are used in toilets.



Water quality :

Drinking water is fitted with aquaguard water purifiers. This ensures safe drinking water quality.Water quality testing for coliform count is done on a regular basis by random sampling in Department of Microbiology.

Rain water harvesting :

The topography of the open area in the campus is such that rain water flows from the upper reaches and gets collected in the campus permitting the construction of small anicuts and rain water harvesting pits in the campus. Thus, 22 rain water harvesting structures have been constructed across the campus to ensure increase in the ground water levels and its availability throughout the year in the bore wells.

The pits are circular in shape with 4' in diameter and 6'in depth, except one which is rectangular and measures 5'x 4'x10'. These structures are lined by R C C rings. The lower layer of the pits is laid with 40mm crushed stones upto a height of 1' 6". Above that another 20mm finely crushed stones are laid up to a height of 1' 6". Rest of the pit is left open for the water to set in. The pit is covered with perforated R C C lid. These pits are maintained and cleaned periodically to prevent silt accumulation, and the efforts have paid rich dividends to the college. The trees in the campus look lush green even in the peak of summer, and the borewell never dries up. The ground water is copious and meets all the requirements of gardening and other non-drinking purposes in the college. [Annexure – V]

The harvesting pits are evenly located in the campus at the following places:

Block	Location	Number of pits	Size	Shape
New Block	New Block	1	5'x 4'x10'	Rectangular
		2	4' X 6'	Circular
Science block	Behind Director's office	1	4' X 6'	Circular
	In front of Examination branch	1	4' X 6'	Circular
IT block	Behind	2	4' X 6'	Circular
	Left side	1	4' X 6'	Circular
Canteen	Between Canteen and IT block	1	4' X 6'	Circular
Biochemistry block	Front	1	4' X 6'	Circular
	Behind	1	4' X 6'	Circular
Commerce block	Behind	1	4' X 6'	Circular
VivekBharti Stage	Near water tank	1	4' X 6'	Circular
MBA block	Behind	1	4' X 6'	Circular
Behind MBA block	Gymnasium (Left side)	2	4' X 6'	Circular
	Gymnasium (Right side)	6	4' X 6'	Circular

Measures for upgrading water management:

1. Need to install low flow faucets and automatic faucets in wash rooms.
2. College should adopt drip irrigation for gardening to achieve “More Crop Per Drop”
3. Need to work on “Water Foot Print” to quantify the consumption of water through meter system.
4. Hardness of water to be tested periodically.

4.4 Green area management

4.4.1 Carbon sequestration

The college has nearly 63 different plant species that includes ornamental plants, potted plants, shrubs, herbs, trees and grass. During the audit all the trees were counted and tagged, their girth and height were measured and the amount of carbon sequestered was calculated. As the data shows a good amount of carbon sequestered the practice of planting trees as a part of “Haritha Haram” would continue to enhance the quality of air in and around the campus. [Annexure -VI]

S.No	Scientific names of the plant
1	*Acalyphawilkesiana tricolor* *Acalyphahispida* *Acalyphawilkesiana* forma *circinata* *Acalyphawilkesiana macrophylla*
2	*Achrus sapota*
3	*Aegle marmelos*
4	*Allamanda violacia* *Allamanda cathartica*
5	*Aloe vera*
6	*Alstoniascholaris*
7	*Alternanthera bettzickiana*
8	*Araucaria heterophylla*
9	*Artabotrysodoratissimus*
10	*Azadirachtaindica*
11	*Bambusa*
12	*Bauhinia racemosa* *Bauhinia blakiana*
13	*Bougainvillea spectabilis* *Bougainvillea rubraplana*
14	*Butea monosperma*
15	*Caesalpiniapulcherrama*
16	*Callistemon speciosus(Bottle brush)*
17	*Calotropis gigantea*
18	*Carica papaya*
19	*Caryota mitis*

20	*Cestrum nocturnum*
21	*Chlorophytumglaucum*
22	*Chrysalidocarpuslutescens*
23	*Crotolariatrifolia*
24	*Cycas revolute*
25	*Cyperusalternifolius*
26	*Delonix regia*
27	*Dieffenbachia seguine*
28	*Dracaena fragrans* *Dracaena marginata* *Dracaena reflexa* *Dracaena sanderiana*
29	*Durantaerecta*
30	*Echeveriaagavoides*
31	*Eucalyptus sideroxylon*
32	*Euphorbia mili*
33	*Ficusreligiosa*
34	*Furcraeagiganteamediopicta*
35	*Hibiscus rosa-sinensis*
36	*Ixorachinensis* *Ixoraduffii* *Ixorasingaporensis*
37	*Jatropha curcas* *Jatropha panduraefolia*
38	*Lagerstroemia indica*
39	*Lantana camara*
40	*Leucaena leucocephala*
41	*Livistoniarotundifolia*
42	*Mangiferaindica*
43	*Micheliachampaca*
44	*Millingtoniahortensis*
45	*Mimusopselengi*
46	*Neolamarckiacadamba*
47	*Neriumodorum*
48	*Nyctanthes arbor-tristis*
49	*Peltophorumpterocarpum*
50	*Phyllanthus emblica*
51	*Plumeria alba*
52	*Polyalthialongifoliavar.pendula*
53	*Pongamiapinnata(biodiesel plant)*
54	*Psidium guajava*
55	*Rosa*sps
56	*Spathodeacampanulata*
57	*Syzygiumcumini*
58	*Tabernaemontanacoronaria* *Tabernaemontanavariegata*

59	*Tamarindusindica*
60	*Tecomastans*
61	*Terminaliacatappa*
62	*Thujaorientalis*
63	*Thunbergiaerecta*

4.4.2 Tree plantation programme

The campus is lush green with trees rich in medicinal values, such as Neem, Areca palm, Bottle brush, Bauhinia, Cassia, Delonix, Jacaranda, Tecoma, Tabebuia, Cymbopogoncitratus, Emblica, Lagerstroemia, Ocimumgratissimum, Mimusopselengi.The management encourages the students and staff to participate in tree plantation programmes regularly on the campus. On 23rd July 2016, Government of Telangana and Hyderabad Metro Railways (HMR) identified the college to initiate `Haritha Haram'**,** and organized a tree plantation program on the campus where nearly 300 saplings that includes few medicinal plants were planted.[Annexure –VII]

5. Awareness Programmes

The college implements several other green practices to make the students conscious of environmental sustainability

- As a part of the student curriculum a course titled "Environmental Studies"(EVS) is taught to them to create and inculcatethe knowledge on different policies, steps to reduce carbon footprint, green practices and follow them regularly.

- Placement of placards and boards like **"Save Electricity" and "Save Water"**all over the campus reminds the students continuously to check their surroundings, to use the energy in an efficient way without wastage.[Annexure –VIII]

- Different awareness programs are organized for students and faculty to understand the importance of waste management for a sustainable environment. Some of them includes conduct of trash audit by students of science club, campaigning by using poster boards, awareness talks on proper segregation of waste into biodegradable and non-biodegradable waste, assigning of projects like Vermicomposting, assignments on organic farming etc.[Annexure IX]

- Encouraging the staff and students to purchase eco- friendly Ganesha and also Clay Ganesha idols with seeds rather than idols prepared with Plaster of Paris.[Annexure X]

- Awareness on simple measures to reduce air pollution, by regularly organizing pollution checks of the two and four wheelers that are used by staff and students.[Annexure XI]

- The college has greEnergy club where students and staff actively organize competitions on burning issues of environment in the form of poster or oral presentation, elocution, best out of waste, model making *etc*, to create awareness on saving planet Earth its sustainability for the future generation.

- Supporting students for their active participation in National seminars or conferences related to themes on environmental consciousness and sustainability.[Annexure XII]

Healthy practices adopted by college:

1. Vermi composting pits
2. Organic farming
3. Green synthesis protocols adopted in chemistry laboratory to reduce the generation of hazardous waste
4. Proper segregation of waste to biodegradable and nonbiodegradable
5. Generation of less E-waste in campus
6. Proper disposal of waste through authorized dealers
7. Recycling of used paper by signing an MOU with ITC
8. Use of one sided paper to lessen the burden of printout papers used.
9. Conduct of online continuous internal exams for PG to reduce paper usage.
10. The examination branch has duplex printers. This enables the complete usage of paper.
11. The construction waste generated in the campus is effectively utilized as filling for new constructions etc
12. The college has installed a finger-based time and attendance biometry system with battery for teaching and non-teaching staff (attendance) and for teaching staff and students in the library

Main Findings

The green audit team has undertaken appropriate procedures to assess and analyze the steps and measures taken by the institute to reduce the carbon footprint. The environmental awareness initiative undertaken by the college is appreciable. It was found that, in general all the staff and students are aware about the importance of today's need to protect the environment for a better tomorrow.

The main findings of the team was some of the best practices adopted by the college like installation of solar panels for a long term carbon neutrality, increasing the number of rain water harvesting pits at different locations to increase the ground water level, recycling of paper with the help of ITC limited, paperless office by conducting online exams, sending messages through SMS *etc*, arrangement of classroom with sufficient lighting and ventilation. The solid waste generated by the college was found to be minimum and necessary measures were taken to segregate the biodegradable and non-biodegradable waste was observed. The amount of carbon sequestered by the plants and trees around the campus shows the best practice of the institute following the guidelines of the state government in implementing the practice of tree plantation programmes regularly. As a part of this event large number of students were made participate to bring a social responsibility in safe guarding the environment. The initiatives and measures taken by the institute guide and motivate the students to follow these in making a sustainable environment for future generation.

Annexure –I

Solar panels

Annexure II

Star rated AC and Refrigerator

Star rating of AC

S.No	Location	Number	Star ratings
1	Director room	1	★★★★★
2	Principal room	1	★★★
3	Examination branch	4	★★★
4	Biochemistry department	1	★★★
5	Biotechnology laboratory	1	★★
6	Seminar hall (Room no 208)	5	★★★
7	Committee room	2	★★★

Star rating of Refrigerator

S.No	Location	Number	Star ratings
1	Principal room	1	★★★★★
2	Biochemistry laboratory	2	★★★
		2	★★★★
3	Biotechnology laboratory	1	★★★
4	Genetics laboratory	1	★★★★
		1	★★★
		1	-
5	Chemistry laboratory	1	★★★★
6	Microbiology laboratory	1	★★★★
		1	★★★★
		3	-

Annexure III

MODE OF TRANSPORT				
MODE OF TRANSPORT	BICYCLE	PUBLIC TRANSPORT	BY WALK	TOTAL
UG I	6/1044	337/1044	49/1044	392/1044
UG II	5/985	313/985	36/985	354/985
UG III	4/989	286/989	57/989	347/989
PG I&II	6/484	74/484	8/484	88/484
Teaching staff	0/119	12/119	11/119	23/119
Non-teaching staff	0/32	5/32	6/32	11/32
TOTAL	21/3653	1027/3653	167/3653	1215/3653
OVER ALL PERCENTAGE	0.57%	28.11%	4.57%	33.26%

Annexure IV

Recycle of Paper

Photos	
	
	
	
	

Annexure V

Rain Water Harvesting Pits

Annexure VI

Carbon Sequestration

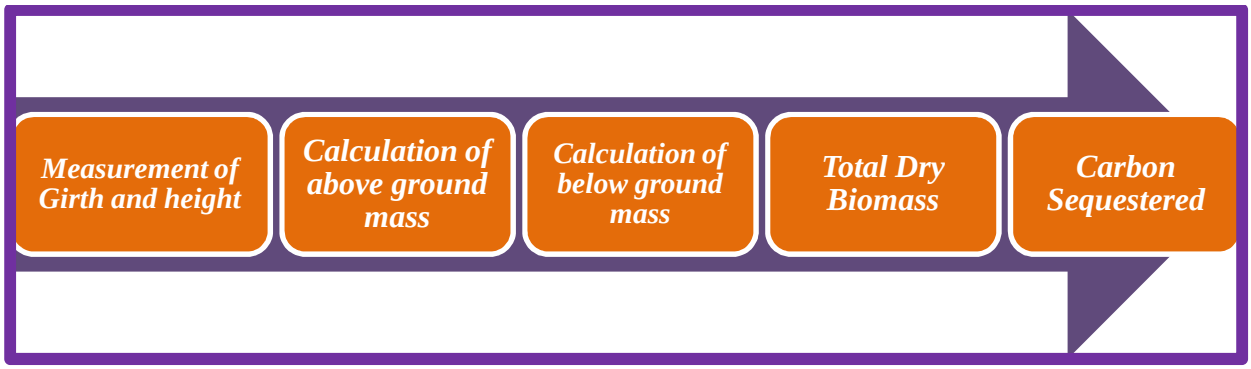
Introduction

Human civilization on the planet Earth with advanced improvement in technology has left behind for the 21st century beginners with an irreparable environmental crisis. Environmental problems include climatic change, tropical deforestation, loss of flora and fauna, desertification, few burning issues that has received serious attention from scientist, citizens and policymakers. The most dominant greenhouse gas (CO_2) accounts nearly 77% of the total global CO_2 (IPCC2007c). It accounts nearly 56% of the total global warming potential among GHGs. Two strategies to reduce it are mitigation and adaptation. Mitigation is defined as a process that reduces the sources of GHGs to lower levels thereby controlling the climate change. "Sustainable land management" aims to prevent land degradation, reduce CO_2, increase carbon sequestration and conserve our biodiversity. Therefore, CO_2 fluxes in between land and atmosphere can be controlled by growing trees in and around our area.

Terrestrial sequestration involves capture and storage of carbon dioxide by plants and store carbon in soil. Photosynthetic process, in plants fixes atmospheric carbon dioxide that is utilized for its survival and growth. During this process the carbon of carbon dioxide becomes a part of a plant within their leaf, stem, root, flower, etc. Long living trees reduces soil erosion and also sequesters the carbon dioxide for a long period of time. When the tree withers or dies, it is decomposed. Along with trees growing of shrubs, small plants and grass can support the trees by storing some amount of carbon. Therefore, biological sequestration is a process where the carbon present in the atmosphere in the form of carbon dioxide is captured by plants and stored in the form of biomass

Determination of CO_2 sequestration by trees:

Methodology:Ravindranath& Ostwald method was used for calculating total carbon sequestered by all trees. This method was used as it is a non-destructive and is designed for tropical plant species. The estimation was done by using two parameters i.e. Height and Girth of a tree and dividing the species zone wise. Carbon sequestration calculation was done using following steps:



Location

The area of this study was ten acres of land that belongs to Bhavan's Vivekananda College of Science, Humanities and Commerce. As the area contains nearly 63 different plant species (trees, herbs, shrubs, potted plants, creepers etc) the biomass and carbon sequestered in the standing woody trees were calculated.

To determine the biomass of different trees a non-destructive method was applied mainly for tropical plantation. The biomass of the tree was calculated on the basis of DBH (Diameter at breast height or Girth at breast height GBH) determined by measuring the girth at breast height that is approximately 1.3 meter above the ground level and tree height. The diameter of tree if greater than 10 cm was measured using a measuring tape.

Calculation

Step 1: Measurement of height and Girth

Height and girth of each tree species is measured during tree inventorization.

Step 2: Calculation of Above Ground Biomass (AGB)

Above Ground Biomass (AGB) – It includes the shoot, branches, leaves, flowers and fruits. It is calculated as follows

$$\text{AGB (Kg)} = \text{Volume of a tree } (m^3) \text{ X Wood density } (Kg/m^3)$$

Where, Volume of the cylindrical shaped tree in $m^{3,}$ is $V = \pi r^2 h$ (r- radius in meters and h – height in meters).Wood density is used from Global density database where, the standard average density is 0.6gm/cm.

Step 3: Calculation of Below Ground Biomass (BGB)

Below ground biomass is the mass of a living root system of any tree and not the fine roots. It is assumed that for any tropical tree, the below ground biomass is 26% (0.26 factor as the root: shoot ratio) of its above ground biomass. Hence it is calculated by using the above ground biomass values.

BGB = AGB (Kg/tree) X 0.26

Step 4:Calculation of Total Dry Biomass

It is the sum of the Above Ground Biomass and Below Ground Biomass.

Total Biomass = AGB + BGB (Kg/tree)

Step 5: Calculation of Carbon

As per international guidelines, carbon sequestered till date is 50% of its total dry biomass. Hence carbon sequestration for individual tree species is calculated using total dry biomass value that is for any plant species, 50% of its biomass is considered as its carbon.

Biomass X 50 %

Step 6:Calculation of Carbon sequestered.

Determination of Weight of carbon dioxide sequestered in the tree,

The weight of CO_2 is Molecular weight of Carbon (12.01) + 2X(15.99-Molecular weight of oxygen).Therefore, the ratio of CO_2 to Carbon is calculated as = 43.99/12.001 = 3.6663

To determine the weight of CO_2 sequestered in the tree, the weight of carbon in the tree is multiplied by 3.6663.

Observation

The tree inventorization process was carried out successfully and the no of trees along with sequestrated carbon was estimated is presented

S.No	Name of the Tree	Botanical name	Family	Average Girth in mts	Average Height in mts	Total Biomass	Carbon sequestered per tree	CO_2 sequestered / tree
1	Neem	*Azadirachtaindica*	Moraceae	0.733	8.098	10.33	5.165	18.94
2	Peepal	*Ficusreligiosa*	Moraceae	0.235	4.6	0.602	0.301	1.102
3	Pongamia	*Pongamiapinnata*	Fabaceae	0.29	7.35	1.46	0.73	2.68
4	Kala jamun	*Syzygiucumini*	Myrtaceae	1.693	4.6	31.29	15.65	57.35
5	Peltophorum	*Peltophorumpterocarpum*	Fabaceae	0.676	6.34	6.88	3.44	12.6
6	Eucalyptus	*Eucalyptus sideroxylon*	Myrtaceae	0.75	10.1	13.38	6.74	24.71
7	Subabul	*Leuaenaleucocephala*	Fabaceae	0.40	10.1	3.84	1.92	7.04
8	Cyperus		Cyperaceae	0.37	10.1	3.28	1.64	6.01
9	Tamarind	*Tamarindusindica*	Fabaceae	0.53	10.1	6.74	3.37	12.4
10	Angir	*Ficus*	Moraceae	0.58	10.1	8.06	4.03	14.78
11	Guava	*Psidiumguajava*	Myrtaceae	0.14	10.1	0.466	0.233	0.85
12	Ashoka	*Polyalthialongifolia*		1.34	5.93	25.28	12.64	46.33
13	Tecoma	*Tecomastans*	Bignoniaceae	1.28	9.76	37.97	18.98	69.59

14	Bottle brush	*Callistemon*	Myrtaceae	0.162	3.66	0.228	0.114	0.417
15	Kadamba	*Neolamarckiacadamba*	Rubiaceae	0.232	3.05	0.39	0.195	0.713
16	Bauhinia	*Bauhiniablakiana*	Fabaceae	0.35	3.97	1.16	0.58	2.13
17	Delonix	*Delonixregia*	Fabaceae	0.79	10.1	14.99	7.5	27.49

S. No	Name of the Tree	Botanical name	No of Trees	CO_2 sequestered/ tree	Total Carbon sequestered
1	Neem	*Azadirachtaindica*	33	18.94	625.02
2	Peepal	*Ficusreligiosa*	5	1.102	5.51
3	Pongamia	*Pongamiavelutina*	4	2.68	10.72
4	Kala jamun	*Syzygiucumini*	5	57.35	286.75
5	Peltophorum	*Peltophorumpterocarpum*	14	12.6	176.4
6	Eucalyptus	*Eucalyptus sideroxylon*	13	24.71	321.23
7	Subabul	*Leuaenaleucocephala*	3	7.04	21.12
8	Cyperus		1	6.01	6.01
9	Tamarind	*Tamarindusindica*	1	12.4	12.4
10	Angir	*Ficus*	1	14.78	14.78
11	Guava	*Psidiumguajava*	1	0.85	0.85
12	Ashoka	*Polyalthialongifolia*	5	46.33	231.65
13	Tecoma	*Tecomastans*	2	69.59	139.18
14	Bottle brush	*Callistemon*	14	0.417	5.838
15	Kadamba	*Neolamarckiacadamba*	9	0.713	6.417
16	Bauhinia	*Bauhinia blakiana*	3	2.13	6.39
17	Delonix	*Delonixregia*	2	27.49	54.98
				Total	**1925.25Kg**

Summary

The present study involves tree inventorization and data analysis on carbon sequestration; it shows that there are 17 different species of trees in and around the campus and the amount of carbon sequesteredby them was found to be**1925.25Kg.**

Reference:

1. A Mary Saral, S SteffySelcia and Keerthana Devi, (2017), Carbon storage and sequestration by trees in VIT University campus, IOP Conf. Series: Materials Science and Engineering 263. 022008 doi:10.1088/1757-899X/263/2/022008.

2. Carbon Inventory Methods- Handbook for Greenhouse Gas Inventory, Carbon Mitigation and Roundwood Production Projects, 2008, N. H. Ravindranath and Madelene Ostwald.

Annexure VII

Tree plantation programmes

Haritha Haram: Tree Plantation 23rd July, 2016

GreEnergy club, NCC unit and NSS unit of the college jointly organized Tree Plantation Program as part of Haritha Haram project of the Telangana Govt. in the college premises. The chief guest for the programme was MrRamachander Reddy IAS, in charge DCP Malkajgiri. The other guests included Md. Rafeeq, ACP Bolaram, Dr. Maithri and MrsJyothi from GHMC.
A total of 300 saplings were planted in the college Campus. The whole program was actively carried out by the students and staff of the college led by the Principal, Prof. Y. Ashok, and Heads of the Departments. Air Comdr. J. L. N Sastry, (Retd.) VSM, Vice Chairman BVB, Sainikpuri Kendra and Col M. Vijay Rao, Hon Dir BVC, Sainikpuri also planted trees as part of the programme.










Tree Plantation in Association with HMR


(https://youtu.be/dHeiXif8qVo)

Green Campus




CLEAN & GREEN

Annexure VIII

Boards to promote “Save Electricity and Save Water”

Annexure IX

Vermicomposting pit

Annexure X

Awareness Programmes (Eco friendly Ganesha)









Annexure XI

Traffic Awareness Programme and Pollution Check







Annexure XII

Papers published related to Energy management :

Green campus maintenance and awareness

Year	Topic	Journal	ISSN or ISBN number	Author name
2018	Green campus- A multifaceted Eco friendly Green practice Approach	New Man International Journal Of Multidisciplinary Studies (Journal no 45886)	ISSN:2348-1390	Mrs. S.ChaitanyaKumari and Dr. P.Naga Padma
2018	An ICT framework for Green Practices	New Man International Journal Of Multidisciplinary Studies (Journal no 45886)	ISSN:2348-1390	Mr. G. Mahesh Kumar, Mr. N.Bhaskar
2018	Challenges as per ICT based NAAC Framework –Environmental Consciousness and Sustainability (Green Practice)	New Man International Journal Of Multidisciplinary Studies (Journal no 45886)	ISSN:2348-1390	Mrs.S.Vanitha
2017	A study on the effects of Cleaning agents (Household) on Seed Germination	International Journal of Advance Research in Science and Engineering	ISSN:2319-8354	Mrs. S.Vanitha, L.Vighnesh, V.Sreekar
2017	Ramcharitmanas mein prakruti aur paryavaran	International conference proceedings – UGC &Ayodhya Research centre	ISBN : 978-1-9776-9384-6	Dr. C. Kameswari
2017	Pattana paryavaranam kattada vaishishtyam – Ramacharitmanas aadhyaramgaa	International conference proceedings – UGC &Ayodhya Research centre	ISBN : 978-1-9776-9384-6	Ms. K. Meena Rani