ENERGY AUDIT REPORT

(September 2016)

Prepared For

Krishna Institute of Medical Sciences Deemed University

Malakapur, Pune-Banglore Highway, Tal.: Karad, Dist.: Satara
Pin Code : 415 539, State : Maharashtra, Country : India

Prepared By

Green Scientific Development (I) Pvt. Ltd.

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1 CERTIFICATE

This is to certified and declared that the Energy Audit Report is prepared for ''Krishna Institute of Medical Sciences Deemed University''(KIMSDU), Satara, Maharashtra on a best efforts, judgment & good practice basis by ''Green Scientific Development (I) Pvt. Ltd. (GSDIPL), Mumbai.

The details contained in this report have been compiled in good faith based on the basis of information provided & shared by Krishna Institute of Medical Sciences Deemed University, Karad and site visit sampling and observation. We further submit that the projections are the management's best estimates and no representation, warranty or undertaking, express or implied is made. We further, no responsibility is accepted by Green Scientific Development (I) Pvt. Ltd and/or its affiliates and/or its Directors, auditors in this report or for any direct or consequential loss arising from any use of the information, statements or forecasts in the report.

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Director, GSDIPL
EMS ISO 14001 Lead Auditor
Mr. Kiran Mahadev Shinde

2 PREFACE

Krishna Institute of Medical Sciences Deemed University appointed Green Scientific Development (I) Pvt Ltd to conduct Energy Audit for checking levels of energy aspects and suggest for the improvement at the KIMSDU, Karad.

In the State Maharashtra district Satara Krishna Institute of Medical Sciences Deemed University (KIMSDU) is a medical education institute offering undergraduate degree and diplomas for post-graduation in various branches of medical sciences. Krishna hospital is committed to provide standard treatments and quality care. Management of Institute is well aware for sustainable development of institutional premises.

The energy audit is aimed to record, quantification energy levels/consumption, refer available records, facts and to explore the possibilities of conserving of energy through better practices.

This report contents the performance assessment& Saving Opportunity, suggestions so that the management can take up the implementation according to investment and payback priorities.

3 ACKNOWLEDGEMENT

This Energy Audit is conducted by GSDIPL for KIMSDU hand in hand with appointed institutional representative &staff with all possible efforts on energy aspect for the Hospital and Premises.

The institutional team had put there all possible involvement to accomplish the task, without which it would not be possible to accomplish satisfactorily.

The common goals kept for accounting & contain energy usage without sacrificing the purpose of use of energy at its optimum requirement.

We are thankful to the Top Management of Institute for appointing us to conduct energy audit& also further thankful for the contribution from ;

Mr. (Dr.) M. V. Ghorpade	- Registrar
Mr. Sataynaryan Mashalkar	- Asstt. Registrar
Mr. Yogesh Kulkarni	- Electrical Engg.

4 ABBREVIATIONS

Abbreviations	Full Form
Asstt.	Assistant
A	Ampere
AC	Alternating Current
AC's	Air Conditioner
Avg.	Average
°C	Degree Centigrade
COP	Co-Efficient Of Performance
DC	Direct Current
Eff.	Efficiency
GSDIPL	Green Scientific Development (I) Pvt. Ltd.
HVAC	Heating Ventilation and Air Conditioning
HP	Horse Power
KIMSDU	Krishna Institute of Medical Sciences Deemed University
KV	Kilo Volt
KvA	Kilo Volt Ampere
kW	Kilo Watts
Kwp	Kilo Watts Power
LPD	Liters Per Day
M or m	Meter
m/c	Machine
Min.	Minimum
mm	Millimeter
MSEDCL	Maharashtra State Electricity Distribution Company Ltd.
PRV	Pressure Reducing Valve
RH	Relative Humidity
Sec.	Second
SPV	Solar Photovoltaic
SWH	Solar Water Heater
THD	Total Harmonic Dispersion
V	Voltage
VFD	Variable Frequency Drive
VRV	variable refrigerant valve

5 EXECUTIVE SUMMARY

Review - Energy Saving Started from Sept 2015 are summarised below

Sr. No	Description	Saving / kWh
1	39 Watt LED Light, Qty - 21 From Sept 2015, Saving	13097
2	Solar System 10 Kwp from Oct 2015, Saving	13096
3	Energy Efficient 750 Kva trans, Install, May 2016 Saving	8212
4	Installation of APFC Panel, May 2016, Saving	103500

The major potential savings along with investment and payback period are given below.

Sr. No.	Energy Conservation Measures	Annual Savings		Investment (Rs. Lakhs)	Simple Payback Period (Months)
		Electricity (kWh)	Rs. Lakhs		
1	Arrestation of compressed air leakages in the system	12958.2	0.91	NIL	Instant
2	Cut-off pressure reduction instead of Pressure Reducing Valve	2407.13	0.16	NIL	Instant
3	Replacement of existing lighting system with LEDs	326700	22.00	-	< 08
4	Use of Solar Evacuated Tube Water Heater for Hot Water Generation	111714.8	7.82	-	36-48
5	Use of Heat Pump for Hot Water Generation	72242.3	5.06	-	12-24
6	Replacement of existing split/window ACs with VRV system	112054	7.84	-	12-24
7	Replacement of existing split/window ACs with 5-star inverter split ACs	241210	16.88	-	36-48

6 BASIC DETAILS

Name of institution	**Krishna Institute of Medical Sciences Deemed University**
Location	Malakapur, Pune - Banglore Highway, Karad - 415 539, Maharashtra, India
Year of Establishment	1984
Activity	Medical Education
Facility	Medical College, Hospitals
Energy Scene	
Major Connected load	Air & Vacuum Compressors, Ovens, AC Units, Lighting, Pumps, Computers, Medical & Other Office Equipment, etc.
Major Energy Sources	Electricity from the Grid
Energy Audit Date	16 September 2016

7 INTRODUCTION

7.1 Preamble

- ✓ With the aim of knowing energy aspects KIMSDU management appointed GSDIPL for the energy audit of KIMSDU.
- ✓ KIMSDU has a facility at Karad, Satara. The Institution is facilitated with the utilities like AC's, Lighting, Geysers, Boilers, Medical Equipment's& office equipment's.
- ✓ This energy audit report for KIMSDU, Karad campus presents data collection, Analysis, Field trials, Observations, Recommendations & General Tips

7.2 Objectives

- ✓ To undertake an energy audit through certified person so as to know &identify areas for energy saving

7.3 Scope of Work

- ✓ To correlate monthly data of for a period of 12 months of normal operation.
- ✓ To study electrical energy monitoring and control system existing at the institute
- ✓ To recommend a suitable system for future monitoring.
- ✓ To study energy aspect for the reference period along with monthly electricity consumption and establish scope for MD control through possible optimization of load factor and through detailed load management study.
- ✓ To undertake a detailed motor load study on major continuously operating motors with the help of a clamp on multi-meter to identify instantaneous motor parameters.
- ✓ Based on above, to evaluate the possibility of replacing major motors with energy efficient motors.
- ✓ To study compressed air & nitrogen distribution system in the plant, in terms of compressor type, make, capacity, loading, motor type / size / loading etc. and to undertake output efficiency test for the operating compressors.
- ✓ To study existing requirements of chilled water/conditioned air provisions at present locations and to identify distinct possibilities of rationalization /savings.
- ✓ To study operation of chilled water/conditioned air with the help of operating records kept and spot measurements taken during the field study and identify COP for chilling compressors in usage and identify scope for optimization through improved operating / maintenance practices.
- ✓ To study existing maintenance practices for chilled water / air conditioning system and recommend areas for improvement in energy efficiency /savings.

- ✓ To identify, evaluate and priorities energy saving opportunities into short, mid and long- term time spans depending upon investments, quantum of savings, skills and time required for implementation, etc
- ✓ To recommend a time-bound action plan for implementation of accepted measures.
- ✓ To prepare draft energy audit report, present to management, undertake necessary modifications based on presentation meeting and submit the final report.

7.4 Methodology

Audit Team

GSDIPL proposed a team of experts for conducting the study and worked in close association with KIMSDU unit personnel.

External

Energy Auditor	: Mr. Shripad Kale	- BEE Certified Energy Auditor
Energy manager	: Mr. Bhurke Bhalchandra	- BEE Certified Energy Manger

Internal

KIMSDU	: Mr. Yogesh Kulkarni	- Electrical Engineer

Documentation

GSDIPL submitted a work plan, checklist to the KIMSDU representative, KIMSDU provided relevant data& Documents, Nominated responsible person by KIMSDU who is involved in energy aspect, sections along with his staff in day to day activity for achieving objective of Audit.

Field Work

GSDIPL undertook an "OPENING MEETING" with all related team and then GSDIPL's team conducted all necessary field trials and measurements, GSDIPL provided all the instruments (List No 1) necessary for conducting the Field trials, Closing Meeting – On table Discussion conducted about field trial and its findings.

Report

- Drafting of Report and its verification by management representative
- Final report submission to the management

List 1: List of the Instruments Used for Measurement

Instrument Name	Specification
Demand Analyzer	Suitable for electrical parameters like voltage, current, frequency, harmonics, active & reactive power, power factor etc.
Clamp-on Power Meter	0 - 1200 kW 0 - 600 Voltage, AC 0 - 800 Voltage, DC 0 - 2000 A, Current, AC / DC
Power Quality Analyzer	3 Ph. 4 Wire Recording Parameters: Voltage, Current, Frequency, Harmonics/ Inter harmonics up to 50th, THD of V, I and KW with K Factor, Transients Voltage, All Power Parameters, Inrush current, Flicker Recording, Graphical, Vectorial, Numeric representation, trending of data, monitoring of events, etc.
Lux Meter	0 - 50,000 lux level (Non-Contact Type)
Digital Thermal Anemometer	0 - 45 m/sec. 3%
Relative Humidity and Temperature Indicator	RH – 10% to 95% Temp. – 0 to 100 ^{0}C
Infrared Thermometers	40 ^{0}C to 500 ^{0}C
Portable Temperature Indicator	50 ^{0}C to 1200 ^{0}C
Stop Watch	Standard

8 ENERGY PERFORMANCE ASSESSMENT AND SAVINGS OPPORTUNITIES

8.1 Electricity Consumption

8.1.1 Electricity Consumption from Grid

A study was conducted to observe the variations in the electricity consumption for the past years. The details of the same are given below.

Table 1. Electricity Consumption (2015)

Sr. No	Month	2015
1	Jan	2,45,929
2	Feb	2,45,422
3	Mar	3,22,926
4	Apr	3,41,002
5	May	3,55,948
6	Jun	3,27,814
7	Jul	3,11,106
8	Aug	3,15,782
9	Sep	3,10,796
10	Oct	3,39,025
11	Nov	2,82,100
12	Dec	2,82,363
Total		**36,80,213**

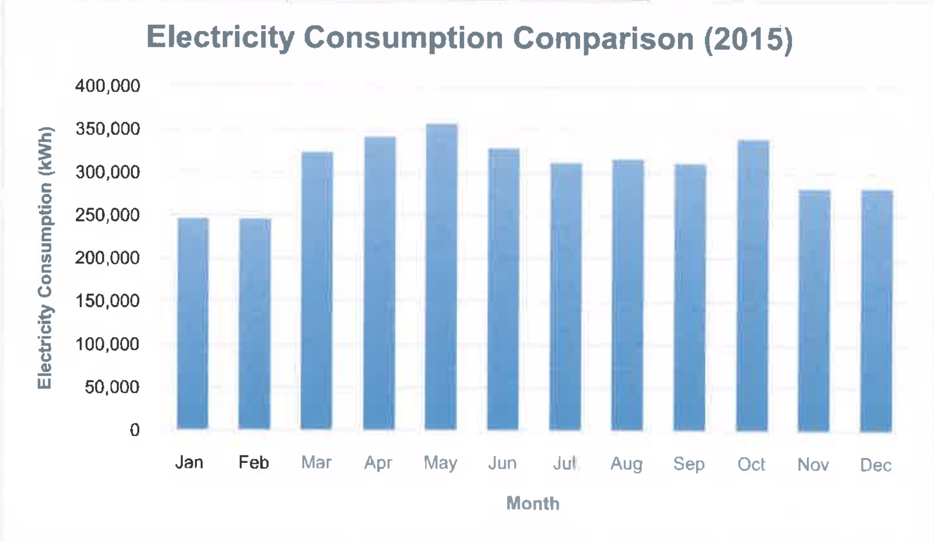

Figure 1. Electricity Consumption (2015)

From the above data, it can be seen that;

- ✓ The minimum electricity consumption was in the month of February because of reduction of cooling load during the month.
- ✓ The maximum consumption is during the month of May because of the high cooling demand.

8.1.2 Electricity Generation using DG sets

During power outage, DG sets were used as a backup option. The diesel consumption month-wise for the year of 2015 given below.

Table 2. Diesel Consumption – 2015

Month	2015
Jan	600
Feb	400
Mar	600
Apr	800
May	400
Jun	800
Jul	300
Aug	1000
Sep	1400
Oct	800
Nov	400
Dec	1200
Total	**8700**

8.2 Regression Analysis

Heating and Cooling degree days (HDD/CDD) are used to indicate the effect of outside air temperature on building energy consumption during a specified time. They represent the number of degrees and the number of days that the outside air temperature at a specific location is lower/higher than a specified base temperature. Since the buildings are air-conditioned and no heating is involved, only CDD have been considered as independent variables.

The relationship between electricity consumption and cooling degree days is represented by the equation y = mx + c, alphabet 'y' represents energy consumption plotted on the y-axis and 'x' represents cooling degree days plotted on the x-axis. The slope of the line 'm' represents degree by which energy consumption varies corresponding to a rise of 'x' degree days. Constant 'C is known as baseload, which is considered to occur as a constant load and is independent of the number of degree days or sales or footfall. R^2 is the coefficient of determination of the model & if its value is above 0.75, then the model is considered to correlate considerably with the independent variable.

Table 3. Cooling Degree Days (2015)

Month	J	F	M	A	M	J	J	A	S	O	N	D
Cooling Degree	2.05	32.31	113.89	148.51	171.98	53.82	22.97	12.4	11.53	41.54	13.06	13.3

Monthly data for cooling degree days (CDD @ 24°C) and electricity consumption for the year January 2015 – December 2015 is shown in Table above. The CDD with a base value of 24°C is selected because the majority of the cooling load is for human comfort condition

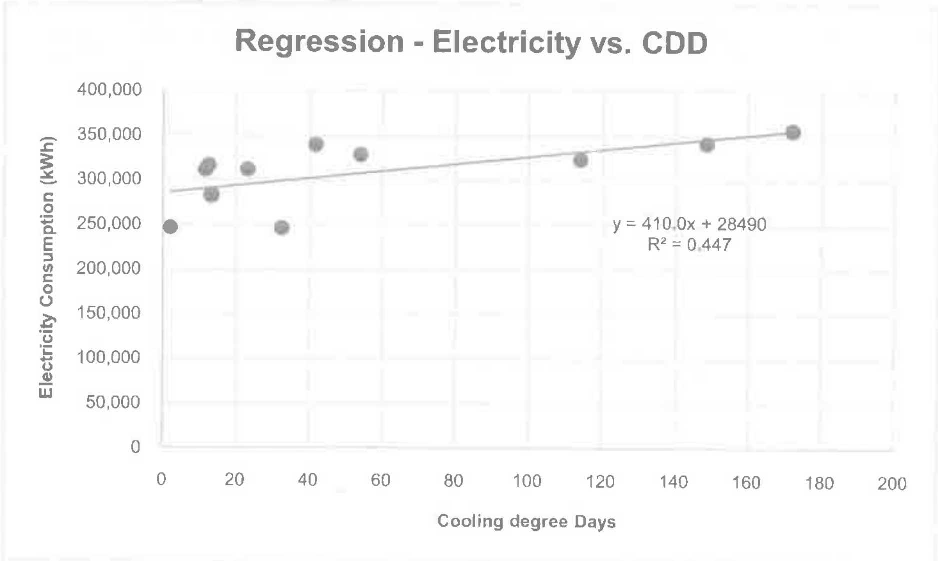

Figure 2. Regression – Electricity vs. CDD

The R^2 (coefficient of determination) value for the regression model is approximately 44.76%, this signifies that the weather (CDD) does not show any strong correlation with the electricity consumption of the facility.

It can be seen from the above figure that the electrical consumption does not comprise only of HVAC systems. However, it has been observed that the major connected load is HVAC systems comprising of approximately 1272 kW. So, there is a possibility of inefficiency in the HVAC systems which is indicated by the lower value of R^2.

8.3 Air Compressor

Air Compressor is one of the energy intensive equipment in the whole premise. It is known that only about 10% of the input energy to the compressor is converted to useful compressed air energy. Performance of the air compressor is of great importance and a significant amount of energy savings can be achieved from it.

In determination of air compressor performance, Free Air Delivery of the compressor is carried out. Presently, there are 2 air compressors present in KIMSDU Dental College & Clinic. During the weekdays, the larger capacity compressor is used for approximately 10 hours. The lower capacity compressor is used only on Saturday. Following is the data of the existing air compressors and air dryer in the college and clinic.

Table 4 (a). Air Compressor Details

Parameters	Units	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5	Comp. 6
Equipment no.	-	AC 01	AC 02	AC 03	AC 04	AC 05	AC 06
Make	-	Ingersoll Rand	Ingersoll Rand	Ingersoll Rand	Ingersoll Rand	KFC	Elgi
Type	-	Screw	Screw	Reciprocating	Reciprocating	Reciprocating	Reciprocating
Capacity	HP	40	10	10	7.5	1.0	5.0
Motor Power	kW	22	11	7.5	5.5	0.75	3.7
Total Current	A	43	23	11	8	0.5	5.2

Table 4 (b). Vacuum Compressor Details

Location of Vacuum Compressor	Equipment No	Make	Type	Capacity (HP)	Motor Power (Kw)	Total Current (A)
Ward No 21 to 28	VC 01	Ingersoll Rand	Reciprocating	10	7.5	13
Ward No 21 to 28	VC 02	Ingersoll Rand	Reciprocating	10	7.5	13
CVTS	VC 03	Ingersoll Rand	Reciprocating	10	7.5	13
Operation Theatre	VC 05	Ingersoll Rand	Reciprocating	05	3.7	8
OT	VC 06	Ingersoll Rand	Reciprocating	02	1.5	2.6
CASUALITY	VC 07	Ingersoll Rand	Reciprocating	02	1.5	2.6
ICU	VC 08	Ingersoll Rand	Reciprocating	02	1.5	2.6

Table 5. Air Dryer Details

Sr. No.	Parameters	Units	Compressor 1
1	Cooling Fluid	-	R 22
2	Max. Temperature	°C	60
3	Max. Ambient Temperature	°C	50
4	Max. Inlet Pressure	barg	14

Another important part of the air compressor and its system is the leakages present in the compressed air distribution and utilization system such as Pipeline, joints, end applications, etc. As we already know that 90% of the input energy to the compressor is wasted, leakages in the system will waste a significant amount of energy. A normal and healthy compressed air system consists of leakages of a quantity of maximum of 8 to 10% of the compressor rated quantity.

Energy Savings Recommendations:

1. **Energy Savings due to arrestation of compressed air leakages in the system**

During the audit, many air leakages were observed in the compressed air system. Assuming the diameter of the leak to be 1 mm at 7.5barg air pressure, the air leakage is approximately equal to 2.3cfm. Considering the specific energy consumption of the air compressor to be 0.18 kW/cfm. The power losses due to 10 leakages of 1 mm diameter is given below.

Table 6. Arrestation of compressed air leakages in the system

Sr. No.	Parameters	Units	Values
1	Diameter of leakage	mm	1
2	Pressure of Air	barg	7.5
3	Number of Leakages	nos.	5
4	Air flow through a single leak point*	cfm	2.3
5	Specific Energy Consumption of Air Compressor	kW/cfm	0.18
6	Total power losses due to leakages	kW	2.07
7	Daily Operating Hours	hours	10
8	Annual Working Days	days	313
9	Annual Energy Savings	kWh/year	6,479
10	Electricity Tariff	Rs./kWh	9.25
11	Annual Cost Savings	Rs./year	59930

https://www.tlv.com/global/TI/calculator/air-flow-rate-through-orifice.html

In actual, the quantity of the leakages will be more and the diameter of the leakage might be less or more. However, it is also recommended to conduct a detailed online compressed air leakage detection of the whole plant. This audit is conducted using Ultrasonic Leak Detector which detects ultrasonic sound released by small leakages which are unheard by a human.

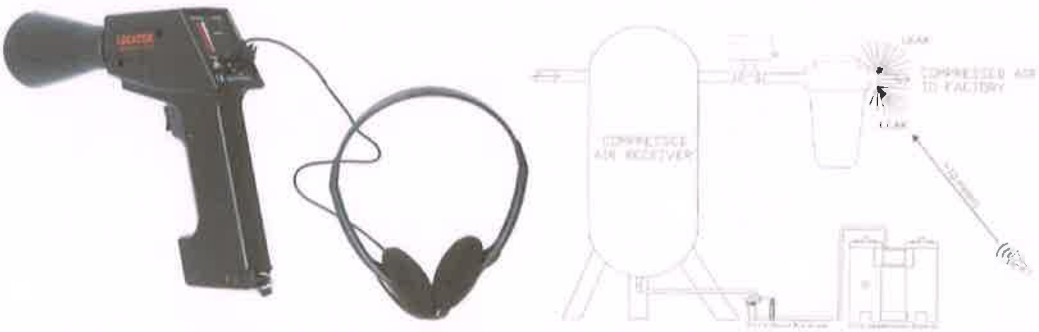

Figure 3. Ultrasonic Compressed Air Leakage Detection

2. Cut-off pressure reduction instead of Pressure Reducing Valve

Artificial demand of the compressors is the additional volume of air which is required because of end uses where air is not regulated, which is the result of supplying the air at a higher pressure than required for any application. Artificial demand increases the supply pressure which directly increases the power consumption of the air compressors.

Figure 4. Artificial Demand of Air Compressor

Presently, the cut-off pressure of the larger capacity air compressor is 7.8 kg/cm^2. The required air pressure is less than 6.5 kg/cm^2. Reduction of the cut-off pressure from 7.8 to 7 kg/cm^2 will give a significant amount of savings. Presently, the pressure reduction is done using a pressure reducing valve which is not a good energy efficiency practice. Savings due to the reduction of cut-off pressure of the compressor is given below.

Table 7. Cut-off pressure reduction instead of Pressure Reducing Valve

Sr. No.	Parameters	Units	Values
1	Cut-off Pressure	bar (g)	7.8
2	Proposed unloading pressure	bar (g)	7
3	Proposed loading pressure	bar (g)	6.5
4	Power consumption after reducing the cut-off pressure by 1 bar (g)	%	3
5	Power reduction due to reduction of cut-off pressure by 0.8 bar (g)	%	2.4
6	Present daily consumption**	kWh	96.07
7	Daily Operating Hours	hours	9
8	Annual Working Days	days	313
9	Annual Energy Savings	kWh/year	6495
10	Electricity Tariff	Rs./kWh	9.25
11	Annual Cost Savings	Rs./year	60078

As per Bureau of Energy Efficiency

****Assuming 70% loading of the air compressor***

8.4 Lighting System (Indoor & Outdoor)

Lighting is the other important system present in the premise which is highly energy intensive. Fluorescent tubelights and CFL were observed commonly in the facility. The facility has already replaced these lights with energy efficient tubelights.

Energy Savings Recommendations:

- **Replacement of existing CFL and Fluorescent tubelights with LEDs**

However, there is still a scope of replacement of the remaining CFL and tubelights with LEDs. Direct reduction in power consumption by 40% is achieved with the replacement. This will also reduce the maximum demand of the whole plant by the same amount. As LEDs are semi-conductor devices, there is also a reduction in power factor improvement capacitor requirements in the facility.

Table 8. Replacement of existing lighting system with LEDs

Sr. No.	Parameters	Units	Values
1	Approximate power savings	kW	14
2	Daily Operating Hours	Hours	10
3	Annual Operating Days	days	313
4	Electricity Tariff	Rs./kWh	9.25
5	Annual Electricity Savings	kWh	43,820
6	Annual Cost Savings	Rs./year	4,05,335

8.5 Hot Water Generation

Hot water is required in the whole facility for different purposes like bathing, cooking and washing. Presently, there is no provision of central hot water system. Instead, different electric heaters are available. Hostels, VIP Rooms, Hospital building and canteen are the locations where hot water is required. The present hot water requirement based on the geyser capacity is given below.

Table 9. Hot water requirements

Geyser Capacity (litres)	Quantity	Total Capacity (litres)
6	30	180
10	22	220
15	4	60
25	4	100
35	5	175
50	60	3000
100	4	400
Total	**129**	**4035**

Based on the total geyser capacity, total hot water generation = 4035 litres. Considering an additional usage of water giving a total of 8075 litres. Assuming this value of hot water required throughout the day.

Energy Savings Recommendations:

- **Use of Solar Evacuated Tube Water Heater for Hot Water Generation**

Solar water heating will generate hot water free of cost with only a small power consumption of the feed water pump. Initial investment will be a little high. However, after the payback period is over, free hot water will be generated without any consumption of electricity. For generation of 8075 litres of hot water every day, following is the energy savings achieved using solar water heater.

Figure 5. Solar Evacuated Water Heater

Table10. Solar Evacuated Tube Water Heater

Sr. No.	Parameters	Units	Values
1	Hot water required @ 55°C	litres/day	8075
2	Annual Solar Radiation Incident	kWh/m^2-year	1748.62
3	Annual Thermal Energy required for 7011 litres hot water	kWh/year	1,08,363.4
4	Thermal Efficiency of Solar Water Heater	%	65
5	Maximum Area of Solar Water Heater required	m^2	516.1
6	Annual Power Consumption of Geysers with 97% efficiency of geyser	kWh/year	1,11,714.8
7	Annual Cost savings with replacement	9.25 Rs./year	10,33,362

- **Use of Heat Pump for Hot Water Generation**

Another alternative to the generation of hot water to solar water heater is a Heat Pump. Heat pump is similar to a refrigerator in construction. The only difference is that the hot side of the system is utilised in a heat pump to supply heat to a space, whereas the cold side of the system is utilised in a refrigerator to remove heat from a space. The electrical energy input to the heat pump is less than the thermal energy output because of its working cycle principle which is represented by COP. COP of a heat pump is the ratio of Thermal Energy supplied to the Electrical Energy Input. Therefore, for the same amount of heat supply, the energy input is lesser than electrical heater/geyser.

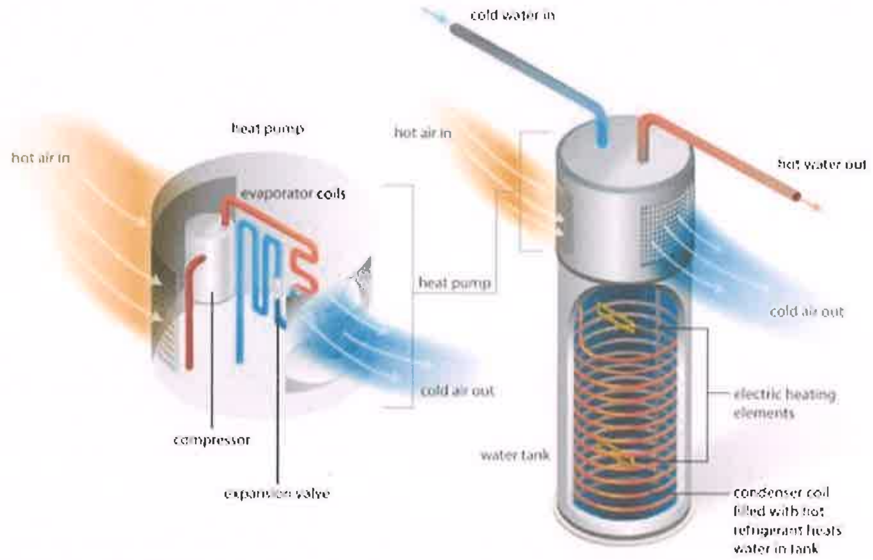

Figure 6. Heat Pump

A centralised heat pump system can be installed for meeting the hot water requirement of the whole facility or individual heat pump units can be installed for each building. The savings associated with the use of heat pump for hot water generation is given below.

Table 41. Heat Pump for Hot Water Generation

Sr. No.	Parameters	Units	Values
1	Hot water required @ 55°C	litres/day	8075
2	Annual Thermal Energy required for 7011 litres hot water	kWh/year	1,08,363.4
3	Annual Power Consumption of Geysers with 97% efficiency of geyser	kWh/year	1,11,714.8
4	COP of a Heat Pump	-	3
5	Annual Electrical Energy input of Heat Pump	kWh/year	36,121.1
6	Annual electrical energy savings	kWh/year	72,242.3
7	Electricity Tariff	Rs./kWh	9.25
8	Annual Cost Savings	Rs./year	6,68,241

A combined system consisting of Solar Evacuated Water Heater along with Heat Pump can be used, thus optimising both renewable as well as energy efficient technology.

8.6 Air Conditioning System

Different buildings in the facility have split/window and duct-able air conditioning units. These air conditioners being smaller ratings have little scope unlike centralized chillers for applying means of energy saving like use of VFDs on AHUs and secondary pumps.

Present day VRF systems which are energy efficient find use only when the interiors are predesigned according to the VRF requirements.

Presently, VRV system of 148 HP is installed in the facility. However, medical college building and library area have split/window ACs. Also, some of the window/split ACs installed are with low BEE star rating.

Energy Savings Recommendations:

- **Replacement of existing split/window ACs with VRV system**

Replacement of existing split/window ACs with a VRV system of an equal size will give energy savings. The amount identified for the replacement of the AC is 210 HP which can be replaced with an equal amount of VRV system. The energy savings achieved with the same is given below.

Table 52. Replacement of Split/Window ACs with VRV system

Sr. No.	Parameters	Units	Values
1	Approximate power savings	kW	35.8
2	Daily Operating Hours	Hours	10
3	Annual Operating Days	days	313
4	Electricity Tariff	Rs./kWh	9.25
5	Annual Electricity Savings	kWh	1,12,054
6	Annual Cost Savings	Rs./year	10,36,499

- **Replacement of existing split/window ACs with 5-star inverter split ACs**

Existing split/window ACs can be replaced with 5-star inverter split ACs. Assuming presently all the split/window ACs are 3-star rated. The energy savings associated with the replacement of the same is given below.

Table 136. Replacement of Split/Window ACs with 5-star inverter split ACs

Sr. No.	Parameters	Units	Values
1	Existing 3-star split AC ISEER	-	3.55
2	5-star split inverter AC ISEER	-	4.75
3	Annual energy savings	%	25
4	Present split/window AC capacity	TR	228
		kW	228
5	Power savings	kW	57
6	Daily Operating Hours	Hours	10
7	Annual Operating Days	days	313
8	Electricity Tariff	Rs./kWh	9.25
9	Annual Electricity Savings	kWh	178410
10	Annual Cost Savings	Rs./year	16,50,292

- **Retrofit of Electronic Savers for Split ACs**

Electronic savers consist of electronic controls which control the operation of the compressor with an additional thermostat. The thermostat which comes in-built the AC provides only a rough control of the temperature setting, which leads to overshoot or undershoot of the set temperature, which results in wastage of energy. When the thermostat fails, the AC works continuously and it is difficult to recognize this failure and take corrective action.

The power saved can be anywhere between 0.2 units per hour to about 1.0 unit per hour depending upon the setting chosen. Savings projected by manufacturers are high (15% to 35%). However, on conservative side if savings are considered to be 20%, payback can be verified. The savings associated with the same is given below.

Table 74. Electronic Savers for Split/Window ACs

Sr. No.	Parameters	Units	Values
1	Present Split/Window AC capacity	TR	236.5
2	Average Power Consumption	kW	307.45
3	Annual Electricity Consumption	kWh/year	2,99,063
4	Savings with Electronic Savers	%	20
5	Annual Electricity Savings	kWh/year	59,813
6	Electricity Tariff	Rs./kWh	9.25
7	Annual Cost Savings	Rs./year	5,53,270
8	Approximate cost of Electronic Saver	Rs.	10,000
9	Total No. of Split/Window units	Nos.	138
10	Approximate Investment	Rs.	13,80,000
11	Simple Payback Period	Years	3.3

8.7 FINDINGS

Various areas for energy conservation are identified, enlisted and overall strategy evolved and discussed with Audit Team and Top management for effective implementation of the recommendations.

Potential Energy Savings & Remarks

Sr. No.	Energy saving Potential	Approximate Saving/year	Remark
1	Saving through Arresting air leakages in compressed air system	10%	Arresting air leakages fully is not practically possible. Air leakages can be effectively reduced to 70% through monitoring and routine maintenance.
2	Pressure reduction in place of PRV The set pressure is 7.8 to 8.0 Kg/cm2 for air compressor. The site fed back was that the actual point of use of compressed air pressure is 6.5 Kg/cm2.	5%	Instead of reducing the pressure using PRV, it is recommended that the set pressure could be 7.0 Kg/cm2. Reduction in set pressure will result in reduction in power consumption.
3	PV Solar System There is scope for installation for PV solar System in area.	61 Lakh	Solar energy and area is available for PV solar system. Near about 500 Kwp PV solar system can be install.
4	Lighting is main consumption in Electrical System and Most of the light fittings are CFL and FTL.	28 Lakh	There is scope to convert near about 4500 Nos. of light fitting (180 Kwh) into LED fitting. Change light fitting into LED light fitting.
5	VRV system. VRV system is good option for Air conditioning System.	20 % against regular AC	Near about 150 HP VRV system can be installed.
6	Replacement of old AC with new Star rated and inverter AC.	10%	Replacement of 5 star rated AC with old AC will give near about 10 % saving

8.8 RECOMANDATIONS

Following suggested implementation priority can be adopted.

1. Saving through Arresting Leakage Losses

   - System leakages are common to both the compressors. The absolute quantity however will be in proportion to the CFM (FAD) capacity of the compressors.
   - Arresting air leakages fully is not practically possible. Air leakages can be effectively reduced to 70% through meticulous routine maintenance.

2. Pressure Reduction

   - The set pressure is 7.8 to 8.0 Kg/cm^2 for 22 KW air compressor that can be verified from display of the compressor and also pressure gauge dial on the receiver tank. The site fed back was that the actual point of use of compressed air deploys P.R.V. to reduce the pressure to 6.5 Kg/cm^2. The difference is about 1.3 Kg/cm^2 to 1.5Kg/cm^2.
   - Instead of reducing the pressure using PRV, it is recommended that the set pressure could be 7.0 Kg/cm^2. Reduction in set pressure by 0.8 Kg/cm^2 to 1.0 Kg/cm^2 will result in reduction in power consumption.

3. Proposition is to switch over to LED lights owing to the following advantages.

   - Emphasis is given on use of LED lights owing to the following features and advantages.
   - Present day LED fittings have come very close to CFL fittings for general illumination needs
   - One to one basis retrofit of LED lights is possible with most conventional type CFL& FTL light fittings
   - Life of LED fittings is 50, 000 burning hours as against about 5000 burning hours of CFL Lights.
   - The life span of 10 times reduces efforts maintenance and labor of replacement as is the case with CFL and FTL lamps. For average use exceeding 10 hours the typical bay back for LED lights works out to 3.5 to 4 years. The rest of the life span of 6 to 6.5 years results total savings.
   - As the savings with LED lights are realized with reduction in wattages for same light output, there is saving in demand as well.
   - As the heat dissipation by LED light is negligible compared to CFL and FTL lights, it saves on air conditioning power also.

4. LED
   - The life span of LED is much longer compared to CFL and FTL. In places where the daily use is say 10 hours (yearly use of 3650 hours), the LED would last for 50,000/3,650 = 13.69 years. This is longer period to realization of payback.
   - Under such circumstances buyers should ask for minimum 25,000 hours at site replacement warranty so the investment is safe.
   - Each fitting may have date embossed / permanently marked for identification so that

replacement can be claimed without hassle.

- As LED lamps have high onetime cost such lamps may be installed with care in public areas or areas where possibility of theft is high.
- A specific area may first be chosen so that practical difficulties of implementation are understood and overcome. Also time is given for performance evaluation and energy saving is registered and documented.

5. Use of Electronic Savers for Air Conditioners
   - These savers have electronic controls which give close over ride on the built in thermostat, thereby offering closer temperature control through modulation of compressor. Generally reputed brands can show 10 to 12% savings in the power consumption. These units could be installed with Window and Split AC units.
   - The thermostat fitted in the air conditioner provides only a crude control of the temperature resulting in overshoot or undershoot of the set temperature, which results in wastage of energy. Further, when the thermostat fails, the A/C works continuously and it is difficult to recognize this failure and take corrective action. This results in wastage of energy

6. Replacement of existing / Old A.C. Units with BEE Star rated A. C. units
   - Life of split or widow air conditioner is considered to be about 8 years. Due fouling and ageing the energy efficiency of these units comes down rapidly as they advance toward life exhaustion.
   - Bureau of Energy Efficiency have assigned star rating for these air conditioners. The annual savings have been shown in the table below. Under well chalked out program if the old AC units whose life is more than 6 years are replaced with star 4 or star 5 AC units of equal capacity the savings are obvious.

7. Use of Alternate Fuel
   - Briquette Firing in place of diesel - At present laundry boilers use diesel as fuel. Bio mass briquettes are proposed as alternate fuel in place of diesel. Comparative presentation on energy charge basis is as follows:

8. Combination of Solar & Briquette Firing
   - Thermal solar can be used for preheating of feed water to the boiler. Major problem faced by most thermal solar systems is hardness of water which chokes up the pipes and corrodes the tubes and pipes.
   - In this case special thermal solar has been taken into consideration that can withstand hard water and work without problems.

8.9 GENERALISED ENERGY CONSERVATION TIPS

Apart from the above-mentioned priorities, there are certain tips that management should examine in future to increase energy efficiency and hence to cut down on energy costs.

8.9.1 Electricity

- ✓ Optimize the tariff structure with utility supplier
- ✓ Schedule your operations to maintain a high load factor
- ✓ Minimize maximum demand by tripping loads through a demand controller
- ✓ Stagger star-up times for equipment with large starting currents to minimize load peaking.
- ✓ Use standby electric generation equipment for on-peak high load periods.
- ✓ Correct power factor to at least 0.95 under rated load conditions.
- ✓ Relocate transformers close to main loads.
- ✓ Set transformer taps to optimum settings.
- ✓ Disconnect primary power to transformers that do not serve any active loads
- ✓ Consider on-site electric generation or cogeneration.
- ✓ Export power to grid if you have any surplus in your captive generation.
- ✓ Check utility electric meter with your own meter.
- ✓ Shut off unnecessary computers, printers and copiers at night

8.9.2 Motors

- ✓ Properly size to the load for optimum efficiency.(High efficiency motors offer of 4 – 5% &higher efficiency than standard motors)
- ✓ Use energy-efficient motors where economical.
- ✓ Use synchronous motors to improve power factor.
- ✓ Check alignment.
- ✓ Provide proper ventilation (For every 10^0C increase in motor operating temperature over recommended peak, the motor life is estimated to be halved)
- ✓ Check for under-voltage and over-voltage conditions.
- ✓ Imbalanced voltage reduces motor input power supply by 3 – 5%, so balance of 3 phase power supply is essential.
- ✓ The Demand efficiency reduces by 5-8% if rewinding is not done properly.

8.9.3 Drives

- ✓ Use variable-speed drives for large variable loads.
- ✓ Use high-efficiency gear sets.
- ✓ Use precision alignment.
- ✓ Check belt tension regularly.
- ✓ Eliminate variable-pitch pulleys.
- ✓ Use flat belts as alternatives to v-belts.
- ✓ Eliminate Eddy Current coupling; synthetic lubricants are useful for large gearboxes.
- ✓ When not needed, switch off them.

8.9.4 Fans

- ✓ Avoid poor flow distribution at the fan inlet by using smooth, well rounded air inlet cones for fan intakes.
- ✓ Clean Filters, Fan Blades & Screens on regular interval. Also minimize fan obstructions from inlet and outlet points.
- ✓ Aerofoil shaped fan blades, are useful and can consider.
- ✓ Use low slip, flat belts and minimize fan speed.
- ✓ Maintain belt tension, by regular checking.
- ✓ Eliminate pitch pulleys variables.
- ✓ For Large variable fan loads, use variable speed drives.
- ✓ Use energy efficient motors for continuous operation
- ✓ Eliminate leaks & Minimize bends in ductwork.
- ✓ When not needed, Turn fans off.

8.9.5 Compressors

- ✓ On positive displacement compressors for Variable loads, consider variable speed drives.
- ✓ Use a synthetic lubricant if permitted by OEM.
- ✓ Ensure lubricating oil temperatures, it should not be too high to avoid oil degradation and lowered viscosity. And should not be too low for condensation contamination.
- ✓ Regularly, clean and change the oil filters.
- ✓ For proper functioning conduct periodic checkup & inspection of compressor intercoolers.
- ✓ To power preheat process, use water heat from a very large compressor.
- ✓ Do an energy audit and follow-up the findings.
- ✓ Establish a efficiency & maintenance scheduled programs for compressors. Make it a part of your continuous energy management program.

8.9.6 Pumps

- ✓ Operate pumping near best efficiency point. Modify pumping to minimize throttling.
- ✓ Adapt to side load variation with variable speed drives or sequenced control of smaller units.
- ✓ Stop running both pumps – add an auto-start for an on-line spare or add a booster pump in the problem area.
- ✓ Use booster pumps for small load as requiring higher pressures. Increase fluid temperature differentials to reduce pumping rates. Repair seals and packing to minimize water waste.
- ✓ Balance the system to minimize flows and reduce pump power requirements.
- ✓ Use siphon effect to advantage: don't waste pumping head with a free-fall (gravity) return.

8.9.7 Blowers

- ✓ For air Intakes, use cone & ducts for smooth & rounded air inlet.
- ✓ Remove obstructions from blower inlet and outlet points.
- ✓ Regularly, clean screens & filters. Replaced essentially.
- ✓ Maintain Blower speed.
- ✓ Keep belt tension as required, use standard OEM suggested belts with low-slip or no-slip.
- ✓ Eliminate variable pitch pulleys.
- ✓ Use variable speed drives for large variable blower loads.
- ✓ Use energy-efficient motors for continuous operation.
- ✓ Turn blowers off when they are not needed.

8.9.8 Compressed Air

- ✓ Install a control system to co-ordinate multiple air compressors.
- ✓ For operating multiple air compressors with most efficient mode - Study part-load characteristic and cycling costs.
- ✓ Match the connected load -Avoid over sizing.
- ✓ Load up modulation-controlled air compressors. (They use almost as much power at partial load as at full load.)
- ✓ Turn off the back-up air compressor until it is needed.
- ✓ Reduce air compressor discharge pressure to the lowest acceptable setting. ***(Reduction of 1 kg/cm² air pressure (8 kg/cm² to 7 kg/cm²) would result in 9% input power savings. This will also reduce compressed air leakage rates by10%)***
- ✓ Use the highest reasonable dryer dew point settings.
- ✓ Turn off refrigerated and heated air dryers when the air compressors are off. Use a control system to minimize heatless desiccant dryer purging.
- ✓ Minimize purges, leaks, excessive pressure drops and condensation accumulation. ***(Compressed air leak from 1 mm hole size at 7 kg/cm² pressure would mean power loss equivalent to 0.5 KW)***
- ✓ Use drain controls instead of continuous air bleeds through the drains.
- ✓ Consider engine-driven or steam-driven air compression to reduce electrical demand charges.
- ✓ Replace standard V-belts with high-efficiency flat belts as the old V-belts wear out. Use a small air compressor when major production load is off.
- ✓ Take air compressor intake air from the coolest (but not air conditioned) location. ***(Every 5°C reduction in intake air temperature would result in 1% reduction in compressor power consumption)***
- ✓ Use an air-cooled after cooler to heat building makeup air in winter, ensure foul for heat exchangers.
- ✓ Be sure that air / oil separators are not fouled.
- ✓ Clean regularly filters and replace it promptly upon alarm. Regularly, monitor pressure drops across suction and discharge of filters.
- ✓ Use properly sized compressed air storage receiver.
- ✓ Minimize disposal costs by using lubricant that is fully demulsible.
- ✓ Find out alternatives to compressed air and use same where ever possible. Example; Blowers for cooling, Hydraulic in place of air cylinders, electric in place of air actuators & pneumatic controls.
- ✓ Use nozzles or venturi - type devices instead of blowing with open compressed air lines.
- ✓ Check for leaking drain valves on compressed air filter / regular sets. Certain rubber-type valves may leak continuously after they age and crack.
- ✓ Industry environments, control packaging lines with high-intensity photocell units instead of standard units with continuous air purging of lenses and reflectors.
- ✓ Do an energy audit and follow-up the findings.
- ✓ Establish a efficiency & maintenance scheduled programs for compress Air. Make it a part of your continuous energy management program.

8.9.9 Chillers

- ✓ Set point check and maintain for chilled water temperature.
- ✓ Use the low temp. Condenser water available that the chiller can handle.
- ✓ Increase the evaporator temperature.
- ✓ When fouled, clean heat exchangers.
- ✓ Replace whenever essential old chillers/compressors with new higher-efficiency models.
- ✓ Use water-cooled in place air-cooled chiller condensers.
- ✓ Use energy-efficient motors for continuous operation.
- ✓ Specify for condenser – 'Fouling factors' clean or replace filters promptly upon alarm.
- ✓ Overcharging of oil is not correct.
- ✓ To co ordinate multiple chillers, install a control system.
- ✓ To determine most efficient mode for operating multiple chillers, perform the study part for knowing load characteristics & cost of cycle.
- ✓ Run the chillers to near base load for the lowest operating costs. Over sizing to match the connected load must be avoided.
- ✓ Off line chillers & cooling towers must be isolated.
- ✓ Do an energy audit and follow-up the findings.
- ✓ Establish a efficiency & maintenance scheduled programs for chillers. Make it a part of your continuous energy management program.

8.9.10 Refrigeration

- ✓ Use water-cooled condensers rather than air-cooled condensers. Challenge the need for refrigeration, particularly for old batch processes. Avoid over sizing – match the connected load.
- ✓ Consider gas-powered refrigeration equipment minimize electrical demand charges.
- ✓ Use "free cooling" to allow chiller shutdown in cold weather. Use refrigerated water loads in series if possible.
- ✓ Convert firewater or other tanks to thermal storage.
- ✓ Don't assume that the old way is still the best – particularly for energy-intensive low temperature systems.
- ✓ Correct inappropriate brine or glycol concentration that adversely affects heat transfer and / or pumping energy. If it sweats, insulate it, but if it is corroding, replace it first.
- ✓ Make adjustments to minimize hot gas bypass operation. Inspect moisture / liquid indicators.
- ✓ Consider change of refrigerant type if it will improve efficiency. Check for correct refrigerant charge level.
- ✓ Inspect the purge for air and water leaks.
- ✓ Do an energy audit and follow-up the findings.
- ✓ Establish a efficiency & maintenance scheduled programs for refrigeration. Make it a part of your continuous energy management program.

8.9.11 HVAC

- ✓ Tune up the HVAC control system.
- ✓ Consider installing a building automation system (BAS) or energy management system (EMS) or restoring an out-of-service one.

- ✓ Balance the system to minimize flows and reduce blower / fan / pump power requirements.
- ✓ Eliminate or reduce reheat whenever possible.
- ✓ Use appropriate HVAC thermostat setback.
- ✓ Use morning pre-cooling in summer and pre-heating in winter (i.e. – before electrical peak hours).
- ✓ Use building thermal lag to minimize HVAC equipment operating time.
- ✓ In winter during unoccupied periods, allow temperature to fall as low as possible without damaging stored materials.
- ✓ Improve control and utilization of outside air.
- ✓ Use air-to-air heat exchangers to reduce energy requirements for heating and cooling of outside air.
- ✓ Reduce HVAC system operating hours (e.g. – night, weekend). Optimize ventilation.
- ✓ Ventilate only when necessary. To allow some areas to be shut down when unoccupied, install dedicated HVAC systems on continuous loads (e.g. – computer rooms).
- ✓ Provide dedicated outside air supply to cleaning rooms, combustion equipment, etc. to avoid excessive exhausting of conditioned air.
- ✓ In dry climates, use evaporative cooling.
- ✓ During unoccupied periods, reduce humidification or dehumidification. Use atomization in place of steam for humidification. Clean HVAC unit coils periodically & Comb mashed fins.
- ✓ To reduce pressure drop, upgrade filter banks it lower fan power requirements. Monthly check HVAC filters and clean, change if appropriate.
- ✓ For proper operation cycle and maintenance check pneumatic controls air compressors.
- ✓ Use high-speed doors or clear PVC strip curtains to isolate air conditioned loading dock areas and cool storage areas.
- ✓ In high bay areas, install ceiling fans to minimize thermal stratification.
- ✓ In areas with high ceilings, relocate air diffusers to required heights. Possible, then reduce ceiling heights.
- ✓ Eliminate obstructions in front of radiators, baseboard heaters, etc.
- ✓ For dust and vapor control, use professionally designed ventilation hoods.
- ✓ Use spot cooling and heating
- ✓ Purchase only high-efficiency models for HVAC window units. Use time controller, for HVAC window units.
- ✓ Short cycle is the result of oversized units in poor humidity control, so don't oversize cooling unit.
- ✓ Install multi-fuelling capability and run with the cheapest fuel available at the time. Consider dedicated make-up air for exhaust hoods.
- ✓ Minimize HVAC fan speeds.
- ✓ In humid climates, consider desiccant drying of air to reduce cooling requirements.
- ✓ Seal leaky HVAC ductwork & around coils.
- ✓ Repair loose or damaged flexible connections including those under air handling units.
- ✓ Eliminate simultaneous heating and cooling during seasonal transition periods.
- ✓ Zone HVAC air and water systems to minimize energy use.
- ✓ Keep regular check on damper blades and linkages.
- ✓ Do an energy audit and follow-up the findings.
- ✓ Establish a efficiency & maintenance scheduled programs for HVAC ystem. Make it a part of your continuous energy management program.

8.9.12 Cooling Towers

- ✓ Control cooling tower fans based on leaving water temperatures.
- ✓ Control to the optimum water temp. as determined from CT and chiller performance.
- ✓ Use two-speed or variable-speed drives for cooling tower fan control if the fans are few. Stage the cooling tower fans with on-off control if there are many.
- ✓ Turn off unnecessary cooling tower fans when loads are reduced.
- ✓ Cover hot water basins (to minimize algae growth that contributes to fouling). Balance flow to cooling tower hot water basins.
- ✓ Periodically clean plugged cooling tower water distribution nozzles. Install new nozzles to obtain a more-uniform water pattern.
- ✓ Replace splash bars with self-extinguishing PVC cellular-film fill.
- ✓ An old counter flow cooling towers, replace old spray-type nozzles with new square-spray ABS practically-non-clogging nozzles.
- ✓ Replace slat-type drift eliminators with high-efficiency, low-pressure-drop, self-extinguishing, and PVC cellular units.
- ✓ If possible, follow manufacturer's recommended clearances around cooling towers and relocate or modify structures, signs, fences, etc. that interfere with air intake or exhaust.
- ✓ Optimize cooling tower fan blade angle on a seasonal and / or load basis.
- ✓ Correct excessive and / or uneven fan blade tip clearance and poor fan balance. Use a velocity pressure recovery fan ring.
- ✓ Divert clean air-conditioned building exhaust to the cooling tower during hot weather. Re-line leaking cooling tower cold water basins.
- ✓ Check water overflow pipes for proper operating level. Optimize chemical use.
- ✓ Consider side stream water treatment.
- ✓ Restrict flows through large loads to design values. Shut off loads that are not in service.
- ✓ Take blow down water from the return water header. Optimize blow down water from the return water header. Automate blow down to minimize it.
- ✓ Send blow down to other uses (Remembers, the blow down does not have to be removed at the cooling tower. It can be removed anywhere in the piping system.) Implement a cooling tower winterization plan to minimize ice build-up.
- ✓ Install interlocks to prevent fan operation when there is no water flow.
- ✓ Do an energy audit and follow-up the findings.
- ✓ Establish a efficiency & maintenance scheduled programs for Cooling tower. Make it a part of your continuous energy management program.

8.9.13 Lightings

- ✓ Reduce excessive illumination levels to standard levels using switching, delamping, etc. (Know the electrical effects before doing delamping.)
- ✓ Aggressively control lighting with clock timers, delay timers, photocells, and / or occupancy sensors.
- ✓ Install efficient alternatives to incandescent lighting, mercury vapour lighting, etc. as follows: low pressure sodium, high pressure sodium, metal halide, fluorescent, mercury vapor, incandescent.
- ✓ Select ballasts and lamps carefully with high power factor and long-term efficiency in mind.
- ✓ Upgrade obsolete fluorescent systems to compact fluorescents and electronic ballasts. Consider lowering the fixtures to enable using less of them.
- ✓ Consider day lighting, skylights, etc for its utilization.
- ✓ Consider painting the walls a lighter color.
- ✓ Using less lighting fixtures or lower wattages.
- ✓ Use task lighting and reduce background illumination.
- ✓ Evaluate exterior lighting strategy w. r. t. its type, use & control.
- ✓ Change exit signs from incandescent to LED, wherever possible.

8.9.14 D G Sets

- ✓ Optimize loading.
- ✓ Use waste heat to generate steam, hot water or preheat processes.
- ✓ Use jacket and head cooling water for process needs.
- ✓ Clean air filters regularly.
- ✓ Insulate exhaust pipes to reduce DG set room temperatures.

8.9.15 Buildings

- ✓ Install windbreaks near exterior doors.
- ✓ Replace single-pane glass with insulating glass.
- ✓ If visibility is not required but light is required, consider replacing exterior windows with insulated glass block.
- ✓ Consider tinted glass, reflective glass, coatings, awnings, overhangs, draperies, blinds and shades for sunlit exterior windows.
- ✓ Use landscaping to advantage.
- ✓ Consider automatic doors, air curtains, strip doors, etc. at high-traffic passages between conditioned and non-conditioned spaces. Use self-closing doors if possible.
- ✓ Use intermediate doors in stairways and vertical passages to minimize building stack effect.
- ✓ Use dock seals at shipping and receiving doors.
- ✓ Bring cleaning personnel in during the working day or as soon after as possible to minimize lighting and HVAC costs.

8.9.16 Waste & Waste water

- ✓ Recycle water, particularly for uses with less-critical quality requirements.
- ✓ Recycle water, especially if sewer costs are based on water consumption.
- ✓ Balance closed systems to minimize flows and reduce pump power requirements. Eliminate once-through cooling with water.
- ✓ Use the least expensive type of water that will satisfy the requirement.
- ✓ Fix up water leaks.
- ✓ Test for underground water leaks. (It's easy to do over a holiday shutdown.)
- ✓ Check water overflow pipes for proper operating level.
- ✓ Provide proper tools for wash down – especially self-closing nozzles.
- ✓ Install efficient irrigation.
- ✓ Reduce flows at water sampling stations.
- ✓ Eliminate continuous overflow at water tanks.
- ✓ Promptly repair leaking toilets and faucets.
- ✓ Use water restrictors on faucets, showers, etc. Use self-closing type faucets in restrooms.
- ✓ Use the lowest possible hot water temperature.
- ✓ Do not use a heating system hot water boiler to provide service hot water during the cooling season – install a smaller, more-efficient system for the cooling season service hot water.
- ✓ If water must be heated electrically, consider accumulation in a large insulated storage tank to minimize heating at on-peak electric rates.
- ✓ Use multiple, distributed, small water heaters to minimize thermal losses in large piping systems.
- ✓ Consider leased and mobile water treatment systems, especially for deionised water.
- ✓ Seal sumps to prevent seepage inward from necessitating extra sump pump operation.
- ✓ Install pre-treatment to reduce TOC and BOD surcharges.
- ✓ Verify the water meter readings.
- ✓ STP: Considering the present scenario of sewage water collection area within campus and the treatment plant few kilometers away from campus, the installation needs improvement. The existing pumps and overall installation is doubted to under capacity by considering the future expansion.

8.9.17 Miscellaneous

- ✓ Meter any unmetered utilities. Know what normal efficient use is. Track down causes of deviations.
- ✓ Shut down spare, idling or unneeded equipment.
- ✓ Make sure that all of the utilities to redundant areas are turned off – including utilities like compressed air and cooling water.
- ✓ Install automatic control to efficiently co-ordinate multiple air compressors, chillers, cooling tower cells, boilers, etc.
- ✓ Renegotiate utilities contracts to reflect current loads and variations.
- ✓ Consider buying utilities from neighbors, particularly to handle peaks.
- ✓ Leased space often has low-bid inefficient equipment.
- ✓ Consider upgrades if your lease will continue for several more years.
- ✓ Adjust fluid temperature within acceptable limits to minimize undesirable heat transfer in long pipelines.
- ✓ Minimize use of flow bypasses and minimize bypass flow rates. Provide restriction orifices in purges (nitrogen, steam, etc.).
- ✓ Eliminate unnecessary flow measurement orifices.
- ✓ Consider alternatives to high pressure drops across valves.
- ✓ Turn off winter heat tracing that is on in summer.