Energy Audit Report
of

M/s Mahaveer Institute of Science and Technology.

Vyasapuri , Bandlaguda, Hyderabad, Telangana - 500043

2018-19

By

SRI GAYATRI ENERGY SERVICES

we support you conserve

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Contents

ACKNOWLEDGEMENT

M/s **Sri Gayatri Energy Services**, Hyderabad places on record its sincere thanks to progressive management of M/s **Mahaveer Institute of Science and Technology** ,Vyasapuri , Bandlaguda Hyderabad, Telangana for entrusting the Energy Audit work of their College.

The study team is appreciative of the keen interest and encouragement shown by

Sri **S. Sudershan Reddy**	Chairman
Sri **S. Surender Reddy**	Secretary
Dr. Sri **HSN Murthy**	Director
Dr. Sri **K.S.S.S.N. Reddy**	Principal

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We trust the data provided by M/s **Mahaveer Institute of Science and Technology** ,Vyasapuri , Bandlaguda, Hyderabad, Telangana personnel is true to their best of knowledge and we didn't verify the correctness of it.

Audit Study team

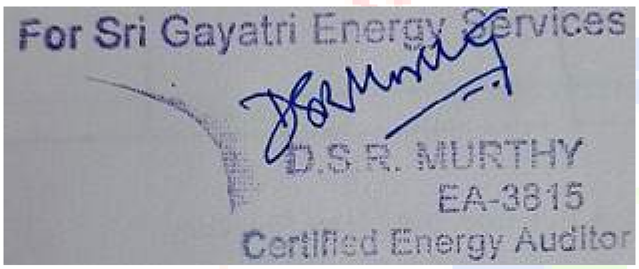
Shri D.S.R.Murthy	Senior Energy Auditor
Shri Durga Rao	Engineer
Shri Sai Ganesh	Engineer

LIST OF INSTRUMENTS USED

- True RMS Power Meter
- Digital Earth Resistance meter (Clamp Type)
- Digital Earth Resistance Meter (Conventional Type , Kyoritsu, Japan)
- Digital Infrared Thermometer (Fluke)

CERTIFICATE

We here by certify that we carried out Energy Audit in the M/s **Mahaveer Institute of Science and Technology** ,Vyasapuri , Bandlaguda, Hyderabad, Telangana during 14 September 2018 and following Observations were presented. The Energy Bills were analyzed for energy consumption , Power factor , Electrical Load distribution , Distribution Losses if any and Recommended to reduce the same .We appreciate the efforts of the M/s **Mahaveer Institute of Science and Technology** ,Vyasapuri , Bandlaguda, ,Telangana for their Pro Energy Conservation measures in this regard.



Executive Summary of Observations

1. A Detailed Walk Through Energy Audit is carried out at the Campus with the following observations.
2. The Power Factor at the Main Incoming panel (after Transformer) is satisfactory .
3. It is observed that some of the Split AC's installed are not of star rated , it is recommended to replace them with minimum 3 star rated AC's as and when the opportunity comes .
4. It is observed that the Existing Fans installed are Energy Inefficient fans which may be replaced as and when opportunity comes with Energy Efficient ones which result in energy savings (Detailed Calculation is enclosed).
5. The Loading of the UPS is observed to be moderate, where ever they are found to be low , It is recommended to check for the opportunity to shift the load to the other UPS and switch off the lightly loaded UPS to reduce the losses.
6. It is observed that the CMD is high and average demand recorded in the current academic year is low. It is recommended to keep this in observation and reduce the CMD if it is consistently low.

Detailed Walk Through Energy Audit scope of work

1. Physical inspection of the premises with reference to Energy Efficient equipment/ Energy Conservation measures/ Renewable Energy.
2. Identifying the Energy saving Opportunities within the premises by installing efficient equipment /devices / systems of the electrical installation.
3. Identifying the Energy Saving opportunities by adopting continuous suitable monitoring methods

Project Schedule :

1. Walk Through Audit : 1 day
2. Report generation : 2-3 Days

Introduction of the Institution

As an Institute committed to quality education, MIST aims at providing learning with a technology-edge. It endeavors to provide consistent training to its students to help them evolve as competent professionals in the highly competitive world. Right from its inception in 2001, it has been tuning itself to meet this objective.

A new civilization is emerging in our lives. This new civilization brings with it a new way of working. Millions are already tuning their lives to the rhythms of tomorrow.

The technological revolution and the forces of globalization are changing the very functioning of the organizations significantly in recent years.

Success nowadays, requires not only the ability to perform according to the requirements of the position, but also the ability to adjust and get along as a member of a working team. Two critical aspects of preparation for success in the workplace are Education and Training, so that you will have the required knowledge, skills and a high level of self-motivation including initiative and responsibility.

Facility Description

The Facility Receives Power supply from TSSPDCL at 11 KV, the installed transformer is 11 KV/433 V transformer of 315 KVA and the Contracted Maximum Demand with TSSPDCL is 120 KVA, The total connected Load is around 671 KW.

Hence it is recommended to reduce the same.

Electrical Load Distribution

The Incoming power supply is from a 11 KV TSSPDCL ,with one Transformers of rating 11kV/433 V 315 KVA , The total connected load is around 671 KW. The emergency supply. taken care by DG Sets . All the three Blocks are equipped with UPS supply for Power back up for the computer systems. The details of the connected Load across the campus is given below

		MAHAVEER INSTITUTE OF SCIENCE AND TECHNOLOGY; HYDERABAD			
Connected Load - 2018-19					
Old Building Connected Load					
S. No	**Location**	**Description (Items)**	**Quantity (Nos)**	**Rating (W)**	**Total (KW)**
1	Building 1 (Old Building)	Split ACs (1.5Ton)	30	1725	51.75
		Fans	240	80	19.2
		Tubes Lights (4')	233	40	9.32
		Tubes Lights (2')	890	20	17.8
		Computers with Monitors	960	250	240
		UPS 6 KVA	6	5.76	34.56
		UPSs-10KVA	3	9.6	28.8
		OHPs	All Labs	Different	108.5
		Lab Equipment	Different	Different	2
		Other Loads (Oven , Fridge, etc)			
		Total Load in KW			**511.9**

NEW Building-Connected Load					
S. No	**Location**				
1	Building 2 (New Building)	**Description (Items)**	**Quantity (Nos)**	**Rating (W)**	**Total (KW)**
		Split ACs (1.5Ton)	0		0
		Fans	170	80	13.6
		Tubes Lights (4')	130	40	5.2
		Computers with Monitors	37	250	9.25
		UPS - 6 KVA	1	5.76	5.76
		UPS - 10 KVA	0	0	0
		OHPs	7	125	0.875
		Lab Equipment	All Labs	Different	122.6
		Other Loads (Hot air Oven, etc)	Different	Different	2.5
		Total Load In KW			**159.79**

The Power Measurements are carried out

Power Measurements AY 2018-19						
Location	Phase	Voltage	Ampere	kVA	Power factor	kW
Main Incoming Power Supply	R	237.8	72.4	17.31	0.98	16.96
	Y	238.5	75.7	18.05	0.995	17.96
	B	241.8	81.3	19.62	0.96	18.83
Old Block	R	239.3	27.5	6.56	0.883	5.80
Main Panel-1	Y	238.7	31.6	7.56	0.87	6.58
	B	241.3	33.5	8.10	0.83	6.72
New Block	R	238.4	18.4	4.39	0.91	3.99
Main Panel	Y	240	21.5	5.16	0.85	4.39
	B	239.1	24.8	5.90	0.78	4.60

The Energy Bills Analysis is carried out to Understand the Consumption pattern of the Institute

M/s Mahaveer Institute of Science & Technology - AY 2018-19											
	UNITS							CHARGES			
Month	KWH	KVAH	PF	Actual KVA	Billed KVA	TOD1	TOD2	Demand	Energy	TOD	Total
NOV19	342533	38033.4	0.9006	120	81.75	0	8503.7	46800	252922	8503.7	308226
OCT19	333642	37070.9	0.9	120	91.8	0	8306.1	46800	246521	8306.1	301628
SEP19	325254	36188.2	0.8987	120	97.44	0	8127	46800	240652	8127	295579
AUG19	314390	35066.3	0.8965	120	88.56	0	7846.1	46800	233191	7846.1	287837
JUL19	303104	33874.2	0.8947	120	71.46	0	7531.1	46800	225263	7531.1	279595
JUn19	294056	32930.6	0.8929	120	51.81	0	7366.5	46800	218988	7366.5	273155
MAY19	287261	32244.5	0.8908	120	96.12	0	7151.2	46800	214426	7151.2	268377
APR19	279645	31432.3	0.8896	120	91.41	0	6780.8	46800	209025	6780.8	262606
MAR19	271029	30506.7	0.8884	120	87.33	0	6780.8	46800	202870	6780.8	256450
FEB19	261401	29451.3	0.8878	120	87	0	6546.1	46800	195851	6546.1	249197
JAN19	256161	28891.6	0.8866	120	66.84	0	6368.6	46800	192129	6368.6	245298
DEC18	251611	28417.5	0.8854	120	54.93	0	6211.8	46800	188976	6211.8	241988

Saving Opportunities

1. The Actual Demand is observed to be recorded less than the CMD , it is recommended to reduce the CMD to 100 KVA from 120 KVA and there by saving of Rs 12500/- per month on account of Demand Charges.
2. The Individual Block wise Power Factor to be improved to reduce the losses .
3. The UPS Loading to be improved OR shift the lightly loaded UPS load to other UPS .

HVAC- Air Conditioning Systems

Introduction of Air Conditioning & Refrigeration System:

The present Air conditioning systems in the college are of Package Units , Split Air Conditioning units of star rated . The Air conditioning is analyzed for energy saving opportunities . The detailed measurements are taken on sample basis at some of the locations .

The Measurements of sample Split AC units are done in blocks and tabulated below

Split Air Conditioners 2018-19												
Sl. No	Location	No. of A.C. Unit	Type of A.C.	Rated TR	Power kw	Inlet Temp.(°c)	Outlet Temp.(°c)	Flow m/sec	Arrived TR	Specific Power KW/TR	COP	EER
1	Old Block	1	Split AC	1.5	1.152	25.3	22.8	0.39	1.23	0.94	3.74	12.79
2	Old Block	1	Split AC	1.5	1.225	24.7	21.9	0.44	1.55	0.79	4.45	15.17
3	Old Block	1	Split AC	1.5	1.35	25.4	23.1	0.45	1.30	1.04	3.39	11.57
4	Old Block	1	Split AC	1.5	1.375	23.7	22.3	0.36	0.63	2.17	1.62	5.53
5	Old Block	1	Split AC	1.5	1.65	24.3	21.7	0.41	1.34	1.23	2.86	9.75
6	Old Block	1	Split AC	1.5	1.525	25.2	22.3	0.38	1.39	1.10	3.19	10.90
7	Old Block	1	Split AC	1.5	1.45	25.7	23.4	0.53	1.53	0.95	3.72	12.68

Energy Efficiency Opportunities

Reduce heat loads

Any reduction in heat loads results in a reduction in required refrigeration capacity and therefore energy consumption. There are three main methods for reducing heat loads:

· Improving insulation.

· Reducing air leakage.

·Reducing incidental and auxiliary gains.

Insulation improvements

The walls of a refrigerated space should be well maintained to guard against damage or degradation of the insulating material.

visual inspection will give first indications of problems while thermographic inspection will show up cold areas where insulation is poor.

- Air leakage

Air can leak through the degraded fabric of an enclosure or through an access such as a door. Taking the steps outlined above should prevent fabric leakage, while reducing air leakage through doors is outlined below:

Reduce temperature lifts

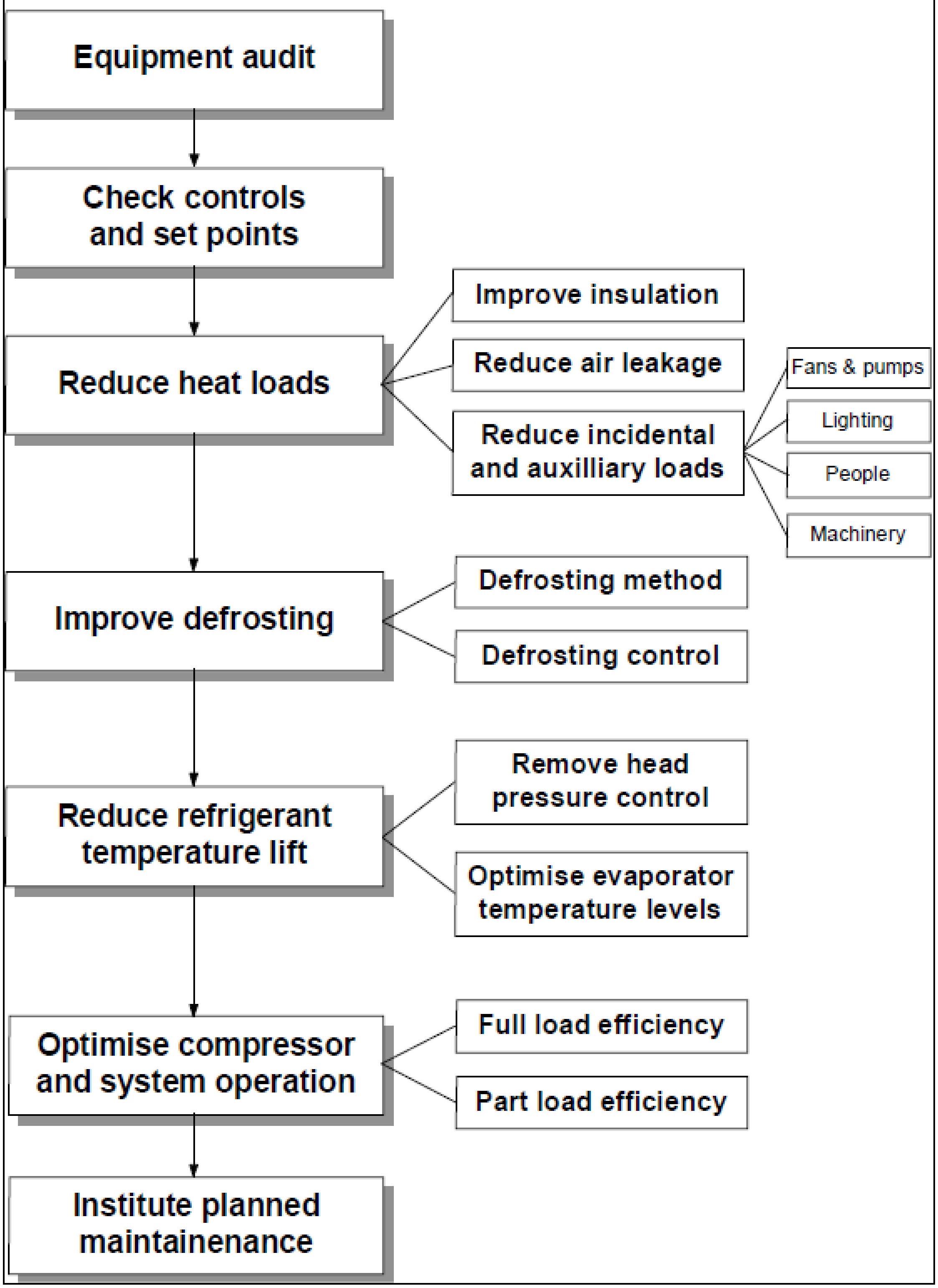
The efficiency of refrigerating plant is dependent upon the size of the temperature lift between the evaporator and the condenser: the smaller the lift the more efficient the system.

- Head pressure control

Many systems maintain a higher lift than is necessary through the use of head pressure control. This practice aims to maintain a high pressure in the condenser to ensure a controlled supply of refrigerant to the evaporator. The control pressure can be reduced using a balanced port thermostatic expansion valve or an electronic expansion valve, while the installation of a liquid line pump can further reduce the need for such control. Lowering the control pressure allows the condensing pressure to fall as the outside temperature falls from the design condition and can improve energy efficiency by50%, particularly during winter. The cost of these measures varies between Rs. 15,000/- to Rs. 1,50,000/- if installed at the time of refrigerant replacement and will normally pay back in about two years.

The Package Units measurements are carried out on sample basis at various locations and following are the details tabulated calculating the SPC (Specific Power Consumption) , EER(Energy Efficiency Ratio), COP(Coefficient of Performance) .

Figure 1: Optimising energy efficiency



Maintenance & Electrical Safety

1. **Electrical Single Line Diagram / Lay Out Diagram / Equipment Layout / Electrical Control diagram**
   i. Check for Unauthorized Temporary Installations
   ii. Modification to be Updated
   iii. SLD reflects the actual installation
   iv. Duly approved by statutory authorities

2. **Importance of Electrical Safety in the Overall Safety System**

   Periodicity of comprehensive Electrical Safety check

   i. Understanding of electrical hazards
   ii. Electrical checkpoints in the safety checklist
   iii. Implementation priority for electrical hazards
   iv. Electrical Work Permit System
   v. Safe Electrical Operating Procedures

3 **Electrical Preventive Maintenance**

   i. Is there an Electrical Preventive Maintenance programme in place
   ii. Is the programme implemented? What is the slippage?
   iii. Are the relevant standards (statutes and non-statutory) referred and incorporated in the EPM programme?
   iv. Electrical Tests, Records, Test Procedure and periodicity (earth resistance, insulation resistance tests)
   v. Is the EPM programme only documented?
   vi. Transformer tests (dielectric strength, acidity, sludge deposits, dissolved gases, etc.) and periodicity
   vii. Periodic calibration of meters (ammeter, voltmeter, relays, temperature gauges) and test instruments (insulation resistance megger, earth resistance megger, multi-meters, etc.)

4 **Earthing System**
   i. Installation as per approved design?
   ii. Installation and Maintenance as per IS 3043?
   iii. Earth resistance measured periodically?
   iv. Test procedure
   v. Acceptable earth resistance values
   vi. Is the earthing system modified when electrical installation is modified?
   vii. Are neutral earth pits independent and separate?
   viii. Are earth pits identified?
   ix. Are two and distinct earth connections provided?
   x. Is the earth continuity tested?
   xi. Is bonding and earthing carried out to avoid ESD hazards?

Annexure I

Conversion factors

CONVERSION TABLES

1 Kcal	3.9685 Btu
1 KWh	3413 Btu
1 KWh	860 kcal
1 Btu	1.055 kJ
1 calorie	4.186 joules
1 hp	746 Watts
1 kg	2.2 lb (pounds)
1 meters	3.28 feet
1 inch	2.54 cm
1 kg/cm^2	14.22 psi
1 atmosphere	1.0332 kg/cm^2
1 kg/cm^2	10 meters of water column @ 4 °C
1 kg/cm^2	9.807 × 10 4 passels
1 Ton of Refrigeration	3023 kcal/hour
1 Ton of Refrigeration	12000 Btu/hour
1 US Gallon	3.785 liters
1 imperial Gallon	4.546 liters
°F	1.8 × °C + 32
°k	°c + 273

Annexure -II -Abbreviations &Definitions

Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
Btu	British thermal unit
Btu/ft²	British thermal units per square foot
J/m²	Joules per square meter
kVA	kilo volt-amperes
kW	kilowatts
kWh	kilowatt-hours
kWh/m²	kilowatt-hours per square meter

Definitions:

Basic definitions of terms

Absorber. The component of the vapour absorption chilling package wherein the refrigerant vapour is absorbed by the liquid absorbent.

Air Handling Unit. An air cooling unit, consisting of a blower or blowers, heat exchanger and filters with refrigerant, chilled water or brine on the tube side to perform one or more of the functions of circulating, cooling, cleaning, humidifying, dehumidifying and mixing of air.

Brine. Solution of anti-freeze substances like Sodium Chloride, Calcium Chloride, Mono-ethylene Glycol, Ethyl Alcohol etc.

Coefficient of Performance. The ratio of Net Refrigerating Effect divided by Compressor Shaft Power or Thermal Power Input. The numerator and denominator should be in the same measuring units.

Compressors. Machines in which compression of refrigerant vapour is effected by the positive action of linear motion of pistons, rotating elements (screws, vanes, scrolls etc.) or conversion of velocity energy to pressure in a centrifugal device.

Compressor, hermetic. Sealed compressor & motor unit, where the electric motor is cooled by the refrigerant and both the compressor and electric motor are not accessible for maintenance.

Compressor, open. Compressor is externally coupled to the prime mover and the refrigerant does not cool the prime mover.

Compressor, semi-hermetic. Compressor motor unit, where the electric motor is cooled by the refrigerant and the compressor is accessible for maintenance.

Condenser. The heat exchanger, which utilizes refrigerant to water/air heat transfer, causing the refrigerant to condense and the water/air to be heated. De-superheating or sub-cooling of the refrigerant may also occur.

Energy Efficiency Ratio. The ratio of Net Refrigerating Effect (Btu/hr) divided by Shaft Power (Watts) or Thermal Power Input (Watts) consumed.

Electric Motor. Electrically operated rotary prime mover.

Enthalpy. The heat content of a substance at a particular temperature.

Engine. Internal combustion engine used as prime mover.

Evaporator. The heat exchanger wherein the refrigerant evaporates and, in the process, cools another fluid I(generally water, brine or air).

Fluid. The substance that is usefully cooled in the chilling package (generally water, brine or air).

Generator. The component of a vapor absorption chilling package wherein the absorbent solution is heated to evaporate the refrigerant and concentrate the absorbent.

Gross Calorific Value. The amount of heat produced per unit of fuel when complete combustion takes place at constant pressure, the products of combustion are cooled to the initial temperature of the fuel and air, and the vapor formed during combustion is condensed.

Net Refrigeration Effect. The useful cooling effect (or heat removal) in the evaporator.

Psychometric Chart. A chart or plotted curves showing the various parameters of air at different temperatures at atmospheric pressure. The parameters shown include dry bulb temperature, wet bulb temperature, relative humidity, moisture content, enthalpy and sensible heat factor.

Refrigerant. The substance that evaporates in the evaporator to provide cooling effect.

Shaft Power. Power at the shaft of any rotary equipment.

Specific Fuel Consumption. The ratio of Thermal Power Input (kg/h of liquid fuel or m3/h of gaseous fuel consumed to the Net Refrigerating Effect (Tons of Refrigeration).

Specific humidity. Mass of water vapor per unit mass of dry air.

Specific Power Consumption. The ratio of Shaft Power (kW) to the Net Refrigerating Effect (Tons of Refrigeration).

Specific Steam Consumption. The ratio of Thermal Power Input (kg/h of steam) to the Net Refrigerating Effect (Tons of Refrigeration).

Speed. The number of revolutions per minute of the shaft.

Temperature, dry bulb. The temperature indicated by any temperature sensing element when held in air.

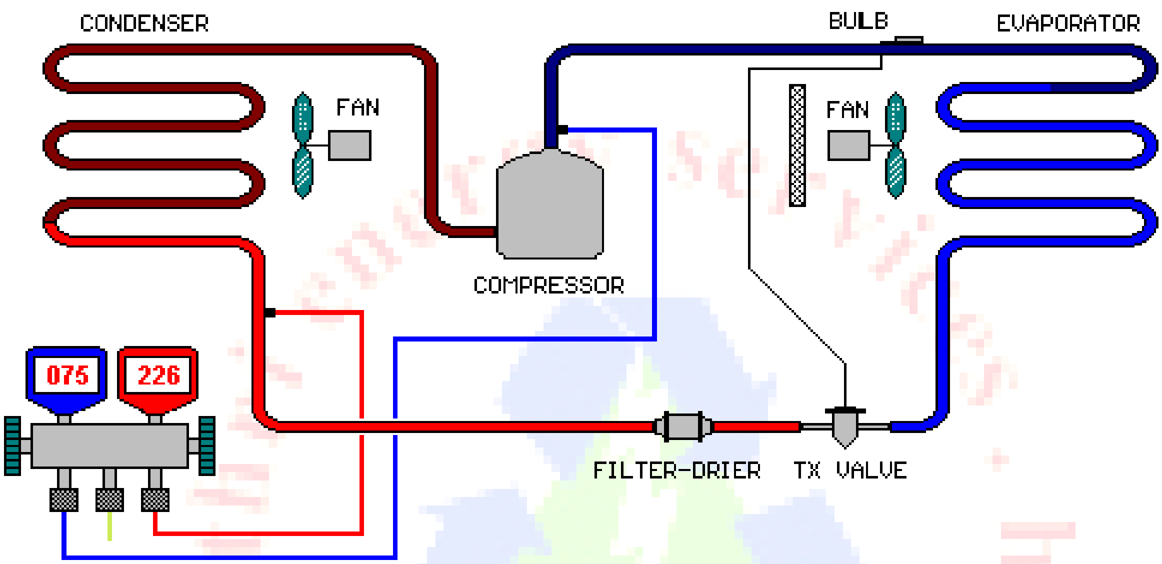
Temperature, Inlet. Temperature measured at the inlet stream of the heat exchanger.

Temperature, Outlet. Temperature measured at the outlet stream of the heat exchanger

Annexure :3 HVAC

Introduction & back ground

Refrigeration Basics



- Refrigeration is the removal of heat from a material or space, so that it's temperature is lower than that of its surroundings.
- When refrigerant absorbs the unwanted heat, this raises the refrigerant's temperature ("Saturation Temperature") so that it changes from a liquid to a gas — it evaporates. The system then uses condensation to release the heat and change the refrigerant back into a liquid. This is called "Latent Heat".
- This cycle is based on the physical principle, that a liquid extracts heat from the surrounding area as it expands (boils) into a gas.
- To accomplish this, the refrigerant is pumped through a closed looped pipe system.
- The closed looped pipe system stops the refrigerant from becoming contaminated and controls its stream. The refrigerant will be both a vapor and a liquid in the loop.

Annexure - 4 Lighting

Recommended illumination Levels as Per IS 3646 Part I-1992			
Type of Interior Activity	Range of Service Illuminanace in Lux	Quality Class of Direct Glare Limitation	Remarks
Education			
Assembly Halls	200-300-500	3	
Teaching Spaces	200-300-500	1	
Lecture Theatres			
i) General	200-300-500	1	
ii) Demo Benches	300-500-700	1	Localized Lighting may be appropriate
iii) Seminar Rooms	300-500-750	1	
iv) Art Rooms	300-500-750	1	
v) laboratories	300-500-750	1	
vi) Libraries	200-300-500	1	
vii)Music Rooms	200-300-500	1	
viii) Sports Hall	200-300-500	1	
ix) Work Shop	200-300-500	1	
x)Computer Work station	300-500-750	1	
xi)Bath Rooms	50-100-150		Supplementary local lighting near mirror
xii) Office Rooms	300-500-750	1	
xiii) Entrance Halls, Lobbies	150-200-300	2	
xiv) Corridors, Passageway, Stairs	50-100-150	2	

Light Source Comparison			
Attributes	**Incandescent**	**CFL**	**LED**
Colur Rendering Index	100	Greater than 80	40-80
Watts/ Lamp	100	23	1
Lumen/Lamp	1600	1600	30
Lumen/Watt	16	60-80	20-30
Life (Hrs)	750	8000	50,000

Colour Rendering Index

1500 K	Candlelight
2680 K	40 W incandescent lamp
3000 K	200 W incandescent lamp
3200 K	Sunrise/sunset
3400 K	Tungsten lamp
3400 K	1 hour from dusk/dawn
5000-4500 K	Xenon lamp/light arc
5500 K	Sunny daylight around noon
5500-5600 K	Electronic photo flash
6500-7500 K	Overcast sky
9000-12000 K	Blue sky

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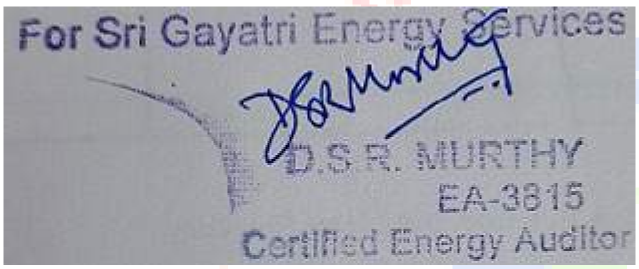

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Detailed Walk Through Energy Audit scope of work

1. Physical inspection of the premises with reference to Energy Efficient equipment/ Energy Conservation measures/ Renewable Energy.
2. Identifying the Energy saving Opportunities within the premises by installing efficient equipment /devices / systems of the electrical installation.
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Project Schedule :

1. Walk Through Audit : 1 day
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Facility Description

The Facility Receives Power supply from TSSPDCL at 11 KV, the installed transformer is 11 KV/433 V transformer of 315 KVA and the Contracted Maximum Demand with TSSPDCL is 120 KVA, The total connected Load is around 719 KW.

Hence it is recommended to reduce the same.

Electrical Load Distribution

The Incoming power supply is from a 11 KV TSSPDCL ,with one Transformers of rating 11kV/433 V 315 KVA , The total connected load is around 719 KW . The emergency supply. taken care by DG Sets . All the three Blocks are equipped with UPS supply for Power back up for the computer systems. The details of the connected Load across the campus is given below

		MAHAVEER INSTITUTE OF SCIENCE AND TECHNOLOGY; HYDERABAD			
Connected Load - 2019-20					
Old Building Connected Load					
S. No	**Location**	**Description (Items)**	**Quantity (Nos)**	**Rating (W)**	**Total (KW)**
1	Building 1 (Old Building)	Split ACs (1.5Ton)	38	1725	65.55
		Fans	275	80	22
		Tubes Lights (4')	255	40	10.2
		Tubes Lights (2')	945	20	18.9
		Computers with Monitors	1025	250	256.25
		UPS 6 KVA	7	5.76	40.32
		UPSs-10KVA	3	9.6	28.8
		OHPs	All Labs	Different	112
		Lab Equipment	Different	Different	2
		Other Loads (Oven , Fridge, etc)			
		Total Load in KW			556.02

NEW Building-Connected Load					
S. No	**Location**				
1	Building 2 (New Building)	**Description (Items)**	**Quantity (Nos)**	**Rating (W)**	**Total (KW)**
		Split ACs (1.5Ton)	0		0
		Fans	185	80	14.8
		Tubes Lights (4')	140	40	5.6
		Computers with Monitors	37	250	9.25
		UPS - 6 KVA	1	5.76	5.76
		UPS - 10 KVA	0	0	0
		OHPs	9	125	1.125
		Lab Equipment	All Labs	Different	124.6
		Other Loads (Hot air Oven, etc)	Different	Different	2.5
		Total Load In KW			**163.635**

The Power Measurements are carried out

Power Measurements AY 2019-20						
Location	Phase	Voltage	Ampere	kVA	Power factor	kW
Main Incoming Power Supply	R	239.1	54.5	13.03	0.97	12.64
	Y	238.4	59.6	14.21	0.93	13.21
	B	241.3	64.3	15.52	0.96	14.89
Old Block	R	238.7	12.4	2.96	0.812	2.40
Main Panel-1	Y	238.5	13.2	3.15	0.789	2.48
	B	240	99.8	23.95	0.879	21.05
New Block	R	239.3	12.9	3.09	0.755	2.33
Main Panel	Y	237.8	14.2	3.38	0.857	2.89
	B	241.8	15.4	3.72	0.885	3.30

The Energy Bills Analysis is carried out to Understand the Consumption pattern of the Institute

M/s Mahaveer Institute of Science & Technology - AY 2019-20												
	UNITS							CHARGES				
Month	KWH	KVAH	PF	Actual KVA	Billed KVA	TOD1	TOD2	Demand	Energy	TOD	Total
OCT20	29733	31441	0.9456	120	30.61	7150	4705	46800	209082.7	11855	267737.7
SPE20	18375	18961	0.969	120	26.99	1463	4381	46800	126090.7	5844	178734.7
AUG20	16266	16836	0.9661	120	7.2	1276	3887	46800	111959.4	5163	163922.4
JUL20	15060	15628	0.9636	120	30.2	1187	3536	46800	103926.2	4723	155449.2
JUN20	13816	14382	0.965	120	14.41	1114	3187	46800	95640.3	4301	146741.3
MAY20	11944	12486	0.956	120	34.09	1020	2666	46800	83031.9	3686	133517.9
APR20	10902	11443	0.952	120	5.38	973	2350	46800	76095.95	3323	126219
MAR20	9406	9947	0.945	120	35.21	879	1892	46800	66147.55	2771	115718.6
FEB20	6542	6790	0.9634	120	24.5	679	1400	46800	45153.5	2079	94032.5
JAN20	3436	3567	0.9632	120	32.56	359	715	46800	23720.55	1074	71594.55
DEC19	609	656	0.9283	120	81.75	42	125	46800	4362.4	167	51329.4
NOV19	342533	380334	0.9006	120	81.75	0	85037	46800	2529221	85037	2661058

Saving Opportunities

1. The Actual Demand is observed to be recorded less than the CMD , it is recommended to reduce the CMD to 100 KVA from 120 KVA and there by savings of Rs 9500/- per month on account of Demand Charges.
2. The Individual Block wise Power Factor to be improved to reduce the losses .
3. The UPS Loading to be improved OR shift the lightly loaded UPS load to other UPS .

HVAC- Air Conditioning Systems

Introduction of Air Conditioning & Refrigeration System:

The present Air conditioning system in the college is of Package Units , Split Air Conditioning units of star rated . The Air conditioning is analyzed for energy saving opportunities . The detailed measurements are taken on sample basis at some of the locations .

The Measurements of sample Split AC units are done in blocks and tabulated below

	Split Air Conditioners 2019-20											
Sl. No	Location	No. of A.C. Unit	Type of A.C.	Rated TR	Power kw	Inlet Temp.(^{0}c)	Outlet Temp.(^{0}c)	Flow m/sec	Arrived TR	Specific Power KW/TR	COP	EER
1	Old Block	1	Split AC	1.5	1.675	24.7	22.8	0.43	1.03	1.63	2.16	7.37
2	Old Block	1	Split AC	1.5	1.355	25.6	21.9	0.37	1.72	0.79	4.47	15.24
3	Old Block	1	Split AC	1.5	1.465	23.9	21.5	0.35	1.06	1.39	2.53	8.65
4	Old Block	1	Split AC	1.5	1.555	23.7	22.3	0.66	1.16	1.34	2.63	8.96
5	Old Block	1	Split AC	1.5	1.275	24.3	22.8	0.55	1.04	1.23	2.86	9.76
6	Old Block	1	Split AC	1.5	1.525	26.7	23.2	0.33	1.45	1.05	3.35	11.43
7	Old Block	1	Split AC	1.5	1.52	27.2	24.1	0.29	1.13	1.34	2.61	8.92

Energy Efficiency Opportunities

Reduce heat loads

Any reduction in heat loads results in a reduction in required refrigeration capacity and therefore energy consumption. There are three main methods for reducing heat loads:

· Improving insulation.

· Reducing air leakage.

·Reducing incidental and auxiliary gains.

Insulation improvements

The walls of a refrigerated space should be well maintained to guard against damage or degradation of the insulating material.

visual inspection will give first indications of problems while thermographic inspection will show up cold areas where insulation is poor.

- Air leakage

Air can leak through the degraded fabric of an enclosure or through an access such as a door. Taking the steps outlined above should prevent fabric leakage, while reducing air leakage through doors is outlined below:

Reduce temperature lifts

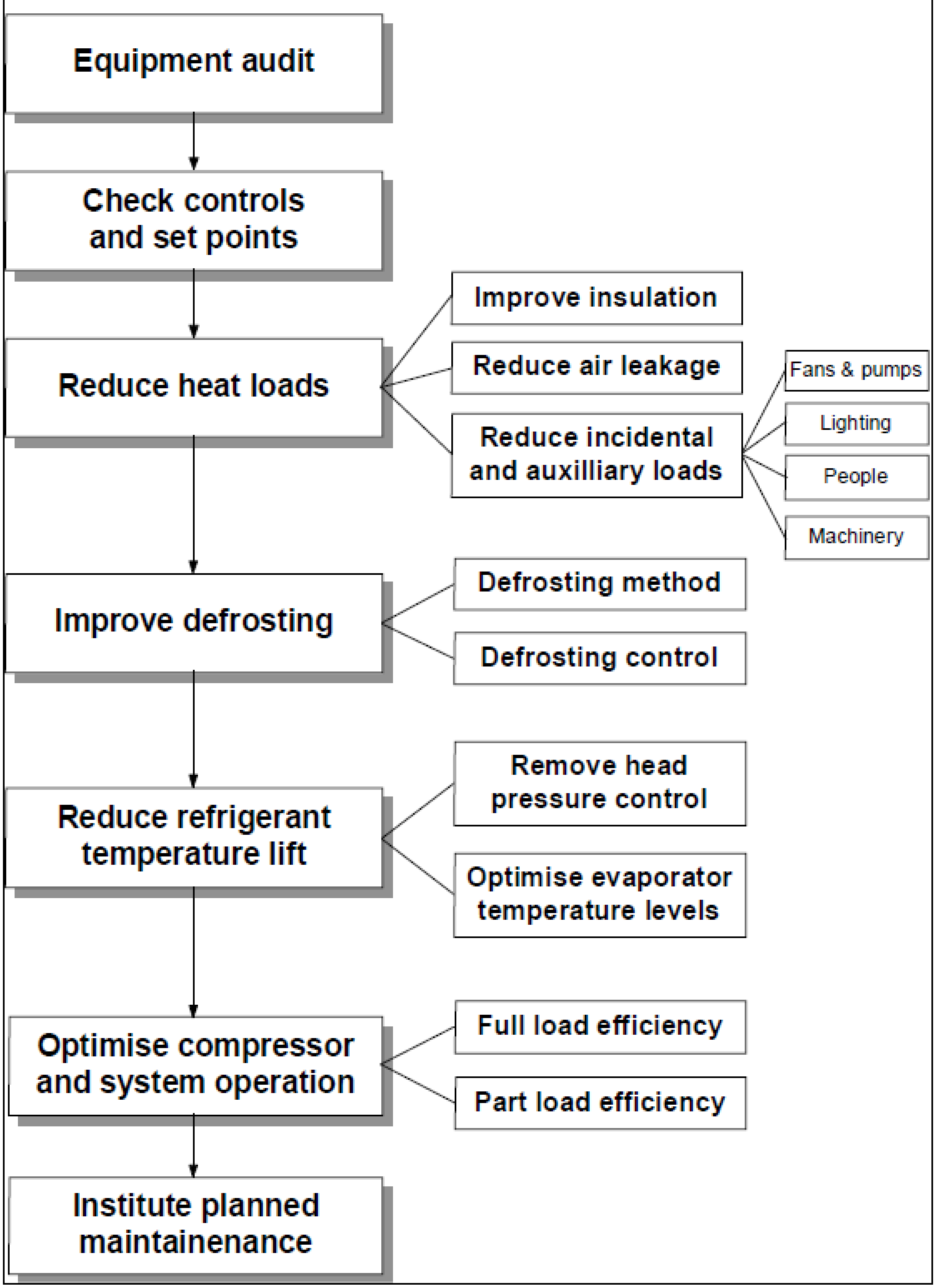
The efficiency of refrigerating plant is dependent upon the size of the temperature lift between the evaporator and the condenser: the smaller the lift the more efficient the system.

- Head pressure control

Many systems maintain a higher lift than is necessary through the use of head pressure control. This practice aims to maintain ahigh pressure in the condenser to ensure a controlled supply of refrigerant to the evaporator. The control pressure can be reduced using a balanced port thermostatic expansion valve or an electronic expansion valve, while the installation of a liquid line pump can further reduce the need for such control. Lowering the control pressure allows the condensing pressure to fall as the outside temperature falls from the design condition and can improve energy efficiency by50%, particularly during winter. The cost of these measures varies between Rs. 15,000/- to Rs. 1,50,000/- if installed at the time of refrigerant replacement and will normally pay back in about two years.

The Package Units measurements are carried out on sample basis at various locations and following are the details tabulated calculating the SPC (Specific Power Consumption) , EER(Energy Efficiency Ratio), COP(Coefficient of Performance) .

Figure 1: Optimising energy efficiency



Maintenance & Electrical Safety

1. **Electrical Single Line Diagram / Lay Out Diagram / Equipment Layout / Electrical Control diagram**
   i. Check for Unauthorized Temporary Installations
   ii. Modification to be Updated
   iii. SLD reflects the actual installation
   iv. Duly approved by statutory authorities

2. **Importance of Electrical Safety in the Overall Safety System**

   Periodicity of comprehensive Electrical Safety check

   i. Understanding of electrical hazards
   ii. Electrical checkpoints in the safety checklist
   iii. Implementation priority for electrical hazards
   iv. Electrical Work Permit System
   v. Safe Electrical Operating Procedures

3 **Electrical Preventive Maintenance**

   i. Is there an Electrical Preventive Maintenance programme in place
   ii. Is the programme implemented? What is the slippage?
   iii. Are the relevant standards (statutes and non-statutory) referred and incorporated in the EPM programme?
   iv. Electrical Tests, Records, Test Procedure and periodicity (earth resistance, insulation resistance tests)
   v. Is the EPM programme only documented?
   vi. Transformer tests (dielectric strength, acidity, sludge deposits, dissolved gases, etc.) and periodicity
   vii. Periodic calibration of meters (ammeter, voltmeter, relays, temperature gauges) and test instruments (insulation resistance megger, earth resistance megger, multi-meters, etc.)

4 **Earthing System**
   i. Installation as per approved design?
   ii. Installation and Maintenance as per IS 3043?
   iii. Earth resistance measured periodically?
   iv. Test procedure
   v. Acceptable earth resistance values
   vi. Is the earthing system modified when electrical installation is modified?
   vii. Are neutral earth pits independent and separate?
   viii. Are earth pits identified?
   ix. Are two and distinct earth connections provided?
   x. Is the earth continuity tested?
   xi. Is bonding and earthing carried out to avoid ESD hazards?

Annexure I

Conversion factors

CONVERSION TABLES

1 Kcal	3.9685 Btu
1 KWh	3413 Btu
1 KWh	860 kcal
1 Btu	1.055 kJ
1 calorie	4.186 joules
1 hp	746 Watts
1 kg	2.2 Ib (pounds)
1 meters	3.28 feet
1 inch	2.54 cm
1 kg/cm^2	14.22 psi
1 atmosphere	1.0332 kg/cm^2
1 kg/cm^2	10 meters of water column @ 4 °C
1 kg/cm^2	9.807 × 10 4 passels
1 Ton of Refrigeration	3023 kcal/hour
1 Ton of Refrigeration	12000 Btu/hour
1 US Gallon	3.785 liters
1 imperial Gallon	4.546 liters
°F	1.8 × °C + 32
°k	°c + 273

Annexure -II -Abbreviations &Definitions

Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
Btu	British thermal unit
Btu/ft²	British thermal units per square foot
J/m²	Joules per square meter
kVA	kilovolt-amperes
kW	kilowatts
kWh	kilowatt-hours
kWh/m²	kilowatt-hours per square meter

Definitions:

Basic definitions of terms

Absorber. The component of the vapour absorption chilling package wherein the refrigerant vapour is absorbed by the liquid absorbent.

Air Handling Unit. An air cooling unit, consisting of a blower or blowers, heat exchanger and filters with refrigerant, chilled water or brine on the tube side to perform one or more of the functions of circulating, cooling, cleaning, humidifying, dehumidifying and mixing of air.

Brine. Solution of anti-freeze substances like Sodium Chloride, Calcium Chloride, Mono-ethylene Glycol, Ethyl Alcohol etc.

Coefficient of Performance. The ratio of Net Refrigerating Effect divided by Compressor Shaft Power or Thermal Power Input. The numerator and denominator should be in the same measuring units.

Compressors. Machines in which compression of refrigerant vapour is effected by the positive action of linear motion of pistons, rotating elements (screws, vanes, scrolls etc.) or conversion of velocity energy to pressure in a centrifugal device.

Compressor, hermetic. Sealed compressor & motor unit, where the electric motor is cooled by the refrigerant and both the compressor and electric motor are not accessible for maintenance.

Compressor, open. Compressor is externally coupled to the prime mover and the refrigerant does not cool the prime mover.

Compressor, semi-hermetic. Compressor motor unit, where the electric motor is cooled by the refrigerant and the compressor is accessible for maintenance.

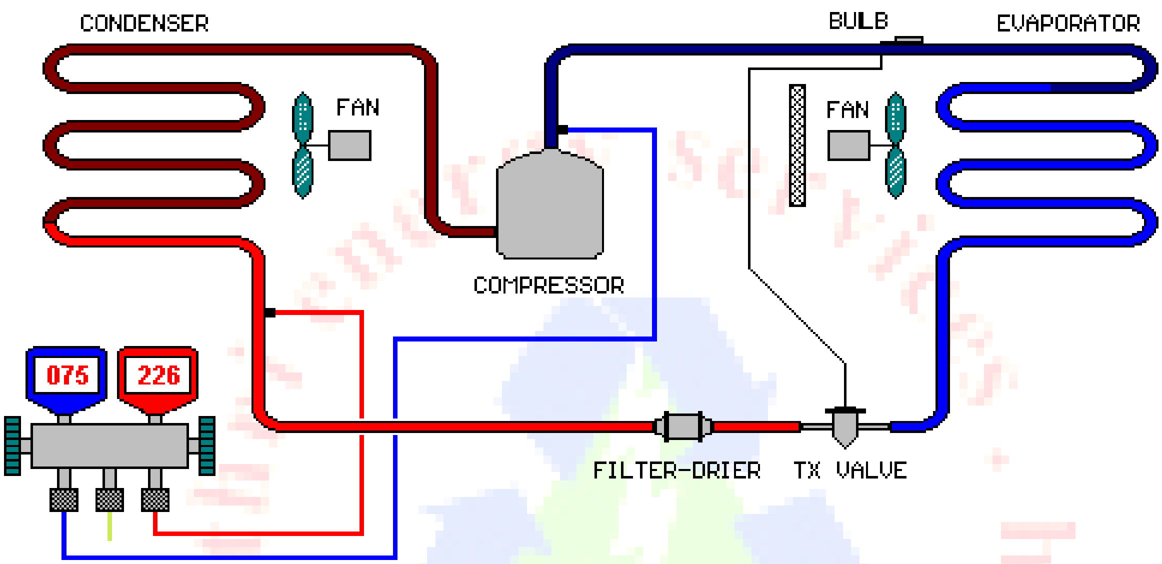
Condenser. The heat exchanger, which utilizes refrigerant to water/air heat transfer, causing the refrigerant to condense and the water/air to be heated. De-superheating or sub-cooling of the refrigerant may also occur.

Energy Efficiency Ratio. The ratio of Net Refrigerating Effect (Btu/hr) divided by Shaft Power (Watts) or Thermal Power Input (Watts) consumed.
Electric Motor. Electrically operated rotary prime mover.
Enthalpy. The heat content of a substance at a particular temperature.
Engine. Internal combustion engine used as prime mover.
Evaporator. The heat exchanger wherein the refrigerant evaporates and, in the process, cools another fluid I(generally water, brine or air).
Fluid. The substance that is usefully cooled in the chilling package (generally water, brine or air).
Generator. The component of a vapor absorption chilling package wherein the absorbent solution is heated to evaporate the refrigerant and concentrate the absorbent.
Gross Calorific Value. The amount of heat produced per unit of fuel when complete combustion takes place at constant pressure, the products of combustion are cooled to the initial temperature of the fuel and air, and the vapor formed during combustion is condensed.
Net Refrigeration Effect. The useful cooling effect (or heat removal) in the evaporator.
Psychometric Chart. A chart or plotted curves showing the various parameters of air at different temperatures at atmospheric pressure. The parameters shown include dry bulb temperature, wet bulb temperature, relative humidity, moisture content, enthalpy and sensible heat factor.
Refrigerant. The substance that evaporates in the evaporator to provide cooling effect.
Shaft Power. Power at the shaft of any rotary equipment.
Specific Fuel Consumption. The ratio of Thermal Power Input (kg/h of liquid fuel or m3/h of gaseous fuel consumed to the Net Refrigerating Effect (Tons of Refrigeration).
Specific humidity. Mass of water vapor per unit mass of dry air.
Specific Power Consumption. The ratio of Shaft Power (kW) to the Net Refrigerating Effect (Tons of Refrigeration).
Specific Steam Consumption. The ratio of Thermal Power Input (kg/h of steam) to the Net Refrigerating Effect (Tons of Refrigeration).
Speed. The number of revolutions per minute of the shaft.
Temperature, dry bulb. The temperature indicated by any temperature sensing element when held in air.
Temperature, Inlet. Temperature measured at the inlet stream of the heat exchanger.
Temperature, Outlet. Temperature measured at the outlet stream of the heat exchanger

Annexure :3 HVAC

Introduction & back ground

Refrigeration Basics



- Refrigeration is the removal of heat from a material or space, so that it's temperature is lower than that of its surroundings.
- When refrigerant absorbs the unwanted heat, this raises the refrigerant's temperature ("Saturation Temperature") so that it changes from a liquid to a gas — it evaporates. The system then uses condensation to release the heat and change the refrigerant back into a liquid. This is called "Latent Heat".
- This cycle is based on the physical principle, that a liquid extracts heat from the surrounding area as it expands (boils) into a gas.
- To accomplish this, the refrigerant is pumped through a closed looped pipe system.
- The closed looped pipe system stops the refrigerant from becoming contaminated and controls its stream. The refrigerant will be both a vapor and a liquid in the loop.

Annexure - 4 Lighting

Recommended illumination Levels as Per IS 3646 Part I-1992			
Type of Interior Activity	Range of Service Illuminanace in Lux	Quality Class of Direct Glare Limitation	Remarks
Education			
Assembly Halls	200-300-500	3	
Teaching Spaces	200-300-500	1	
Lecture Theatres			
i) General	200-300-500	1	
ii) Demo Benches	300-500-700	1	Localized Lighting may be appropriate
iii) Seminar Rooms	300-500-750	1	
iv) Art Rooms	300-500-750	1	
v) laboratories	300-500-750	1	
vi) Libraries	200-300-500	1	
vii)Music Rooms	200-300-500	1	
viii) Sports Hall	200-300-500	1	
ix) Work Shop	200-300-500	1	
x)Computer Work station	300-500-750	1	
xi)Bath Rooms	50-100-150		Supplementary local lighting near mirror
xii) Office Rooms	300-500-750	1	
xiii) Entrance Halls, Lobbies	150-200-300	2	
xiv) Corridors, Passageway, Stairs	50-100-150	2	

Light Source Comparison			
Attributes	**Incandescent**	**CFL**	**LED**
Colur Rendering Index	100	Greater than 80	40-80
Watts/ Lamp	100	23	1
Lumen/Lamp	1600	1600	30
Lumen/Watt	16	60-80	20-30
Life (Hrs)	750	8000	50,000

Colour Rendering Index

1500 K	Candlelight
2680 K	40 W incandescent lamp
3000 K	200 W incandescent lamp
3200 K	Sunrise/sunset
3400 K	Tungsten lamp
3400 K	1 hour from dusk/dawn
5000-4500 K	Xenon lamp/light arc
5500 K	Sunny daylight around noon
5500-5600 K	Electronic photo flash
6500-7500 K	Overcast sky
9000-12000 K	Blue sky

Energy Audit Report
of

M/s Mahaveer Institute of Science and Technology,

Vyasapuri , Bandlaguda, Hyderabad, Telangana - 500043

2021-22

By

SRI GAYATRI ENERGY SERVICES

we support you conserve

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INSTITUTE OF SCIENCE & TECHNOLOG
Bandlaguda, Hyd-500 005

Contents

ACKNOWLEDGEMENT

M/s **Sri Gayatri Energy Services**, Hyderabad places on record its sincere thanks to progressive management of M/s **Mahaveer Institute of Science and Technology** ,Vyasapuri , Bandlaguda Hyderabad, Telangana for entrusting the Energy Audit work of their College.

The study team is appreciative of the keen interest and encouragement shown by

Smt. **S. Jaya Lakshmi**	Chairperson
Sri **S. Surender Reddy**	Secretary
Dr. Sri **HSN Murthy**	Director
Dr. Sri .**B.V.Sanker Ram**	Principal

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Disclaimer

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We trust the data provided by the M/s **Mahaveer Institute of Science and Technology** ,Vyasapuri , Bandlaguda, Hyderabad, Telangana personnel is true to their best of knowledge and we didn't verify the correctness of it.

Audit Study team

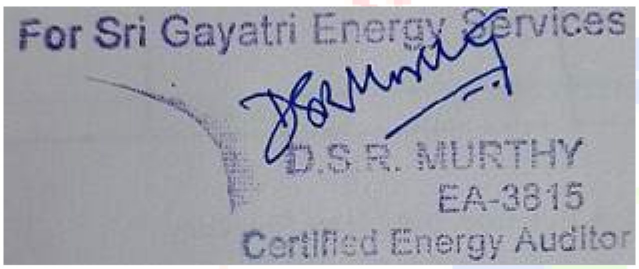
Shri D.S.R.Murthy	Senior Energy Auditor
Shri Durga Rao	Engineer
Shri Sai Ganesh	Engineer

LIST OF INSTRUMENTS USED

- True RMS Power Meter
- Digital Earth Resistance meter (Clamp Type)
- Digital Earth Resistance Meter (Conventional Type , Kyoritsu, Japan)
- Digital Infrared Thermometer (Fluke)

CERTIFICATE

We here by certify that we carried out Energy Audit in M/s **Mahaveer Institute of Science and Technology** ,Vyasapuri , Bandlaguda, Hyderabad, Telangana during 27 Dec 2021 and the observations were presented below. The Energy Bills were analyzed for energy consumption ,Power factor , Electrical Load distribution , Distribution Losses if any and Recommendations were made to reduce the same .We appreciate the efforts of the M/s **Mahaveer Institute of Science and Technology** ,Vyasapuri , Bandlaguda, ,Telangana for their Pro Energy Conservation measures in this regard.



Executive Summary of Observations

1. A Detailed Walk Through Energy Audit is carried out at the Campus with te following observations.
2. The Power Factor at the Main Incoming panel (after Transformer) is satisfactory .
3. The Power Factor at the individual Blocks needs further improvement , it is recommended to install small PF improvement capacitor banks at the individual Blocks(Old / New Blocks) to improve the PF and reduce the losses.
4. It is observed that the Existing Fans installed are Energy Inefficient ones which may be replaced as and when opportunity comes with Energy Efficient fans which result in energy savings (Detailed Calculation is enclosed).
5. It is observed that some of the Split AC's installed are not of star rated , it is recommended to replace them with minimum 3 star rated AC's as and when the opportunity comes .
6. It is recommended to install small capacitor banks at the Main Incomer of the Block panels to improve the Power Factor and reduce the losses.
7. The Loading of the UPS is observed to be moderate, where ever they are found to be low , It is recommended to check for the opportunity to shift the load to the other UPS and switch off the lightly loaded UPS to reduce the losses.
8. It is observed that the CMD is high and average demand recorded in the current academic year is low, it is recommended to keep this in observation and reduce the CMD if it is consistently low.
9. The Electrical machine load is though its high the diversity is low hence no recommendation for this load.

Detailed Walk Through Energy Audit scope of work

1. Physical inspection of the premises with reference to Energy Efficient equipment/ Energy Conservation measures/ Renewable Energy.
2. Identifying the Energy saving Opportunities within the premises by installing efficient equipment /devices / systems of the electrical installation.
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Success nowadays, requires not only the ability to perform according to the requirements of the position, but also the ability to adjust and get along as a member of a working team. Two critical aspects of preparation for success in the workplace are Education and Training, so that you will have the required knowledge, skills and a high level of self-motivation including initiative and responsibility.

Facility Description

The Facility Receives Power supply from TSSPDCL at 11 KV, the installed transformer is 11 KV/433 V transformer of 315 KVA and the Contracted Maximum Demand with TSSPDCL is 120 KVA, The total connected Load is around 781 KW.

At present due to Covid 19 Lock downs the Demand is not reaching close to the 80 % value of the CMD .

Hence it is recommended to reduce the same.

Electrical Load Distribution

The Incoming power supply is from a 11 KV TSSPDCL ,with one Transformers of rating 11kV/433 V 315 KVA , The total connected load is around 781 KW . The emergency supply. taken care by DG Sets . All the three Blocks are equipped with UPS supply for Power back up for the computer systems. The details of the connected Load across the campus is given below

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S. No	**Location**	**Description (Items)**	**Quantity (Nos)**	**Rating (W)**	**Total (KW)**
1	Building 1 (Old Building)	Split ACs (1.5Ton)	43	1725	74.2
		Fans	294	80	23.52
		Tubes Lights (4')	270	40	10.8
		Tubes Lights (2')	1000	20	20
		Computers with Monitors	1040	250	260
		UPS 6 KVA	10	5.76	57.6
		UPSs-10KVA	4	9.6	38.4
		OHPs	21	125	2.63
		Lab Equipment	All Labs	Different	120.75
		Other Loads (Oven , Fridge, etc)	Different	Different	2
		Total Load in KW			**609.9**

NEW Building-Connected Load - 2021 -22					
S. No	**Location**				
1	Building 2 (New Building)	**Description (Items)**	**Quantity (Nos)**	**Rating (W)**	**Total (KW)**
		Split ACs (1.5Ton)	0		0
		Fans	203	80	16.24
		Tubes Lights (4')	155	40	6.2
		Computers with Monitors	37	250	9.25
		UPS - 6 KVA	1	5.76	5.76
		UPS - 10 KVA	0	0	0
		OHPs	11	125	1.38
		Lab Equipment	All Labs	Different	130.55
		Other Loads (Hot air Oven, etc)	Different	Different	2.5
		Total Load In KW			**171.88**

The Power Measurements are carried out

Power Measurements AY - 2021-22						
Location	Phase	Voltage	Ampere	kVA	Power factor	kW
Main Incoming Power Supply	R	239.1	61.3	14.76	0.99	14.7
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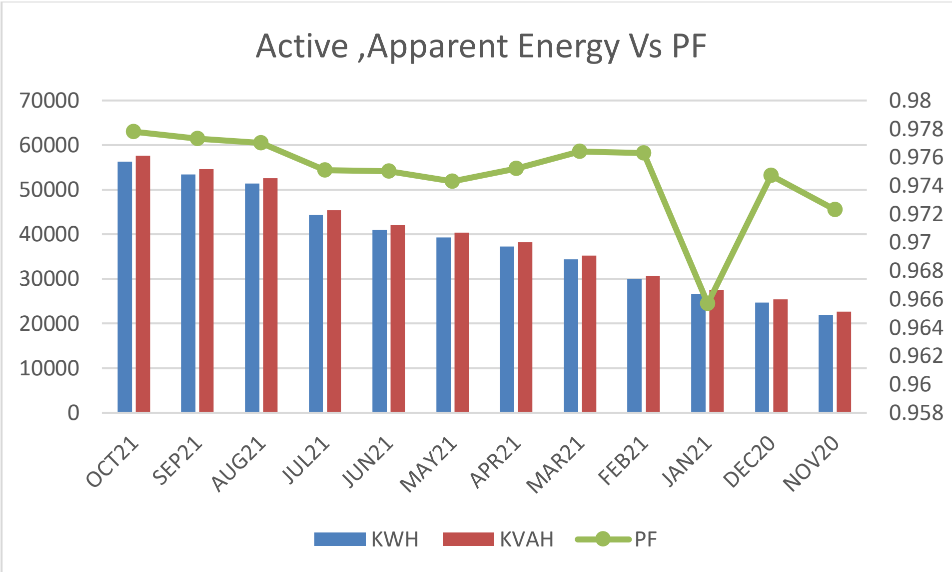
	B	241.3	63.7	15.38	0.99	15.34
Old Block	R	239.3	14.1	3.37	0.632	2.13
Main Panel-1	Y	237.8	12.2	2.92	0.398	1.16
	B	241.8	15.4	3.72	0.77	2.89
New Block	R	238.7	11.8	2.83	0.722	2.04
Main Panel	Y	238.5	12.1	2.91	0.77	2.24
	B	240	8.3	2	0.88	1.76

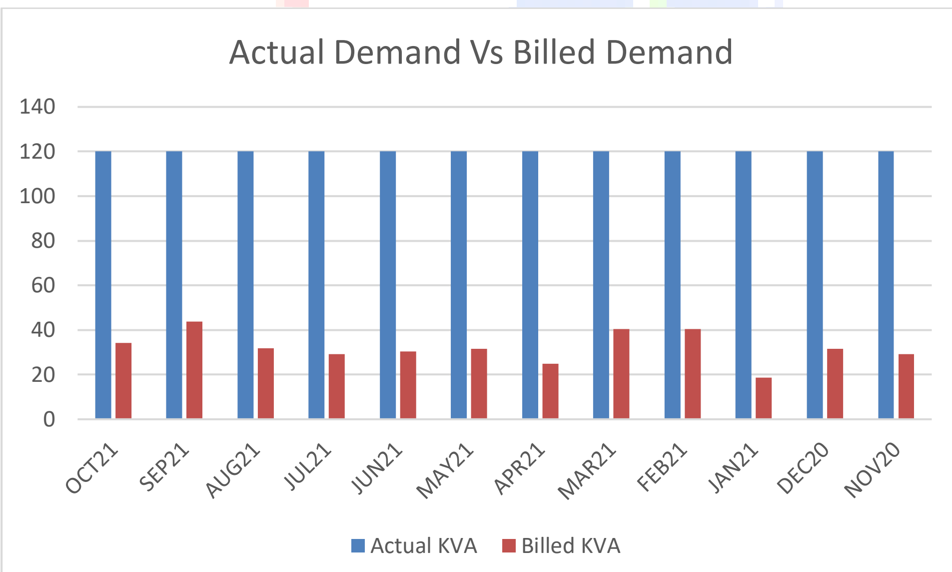
The Energy Bills Analysis is carried out to Understand the Consumption pattern of the Institute

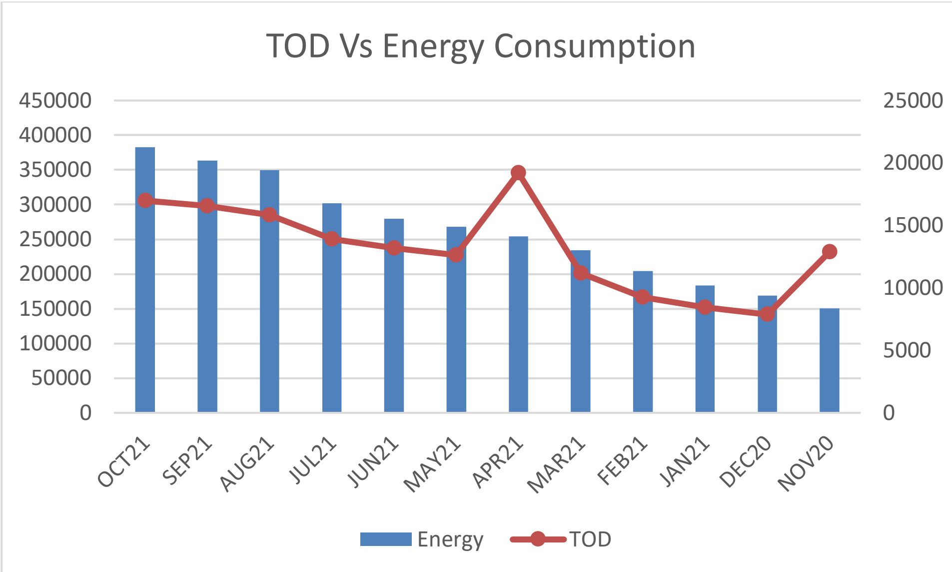
M/s Mahaveer Institute of Science & Technology; Hyderabad, AY - 2021-22											
	UNITS							CHARGES			
Month	KWH	KVAH	PF	Actual KVA	Billed KVA	TOD1	TOD2	Demand	Energy	TOD	Total
OCT21	56312	57587	0.9778	120	34.3	4785	12213	46800	382953.6	16998	446751.6
SEP21	53435	54675	0.9773	120	43.76	4618	11962	46800	363588.8	16580	426968.8
AUG21	51335	52541	0.977	120	31.82	4461	11353	46800	349397.7	15814	412011.7
JUL21	44321	45453	0.9751	120	29.21	3823	10093	46800	302262.5	13916	362978.5
JUN21	40998	42045	0.975	120	30.31	3623	9559	46800	279599.3	13182	339581.3
MAY21	39307	40343	0.9743	120	31.69	3517	9093	46800	268281	12610	327691
APR21	37262	38209	0.9752	120	24.96	10538	8658	46800	254089.9	19196	320085.9
MAR21	34431	35261	0.9764	120	40.46	3222	7958	46800	234485.7	11180	292465.7
FEB21	29999	30726	0.9763	120	40.46	2435	6823	46800	204327.9	9258	260385.9
JAN21	26632	27576	0.9657	120	18.57	2175	6250	46800	183380.4	8425	238605.4
DEC20	24773	25416	0.9747	120	31.64	2041	5827	46800	169016.4	7868	223684.4
NOV20	22014	22641	0.9723	120	29.21	7773	5128	46800	150562.7	12901	210263.7

Saving Opportunities

1. The Actual Demand is observed to be recorded less than the CMD , it is recommended to reduce the CMD to 100 KVA from 120 KVA and there by saving of Rs 9500/- per month on account of Demand Charges.
2. The Individual Blockwise Power Factor to be improved to reduce the losses .
3. The UPS Loading to be improved OR shift the lightly loaded UPS load to other UPS .


Active ,Apparent Energy Vs PF
70000
60000
50000
40000
30000
20000
10000
0
0.98
0.978
0.976
0.974
0.972
0.97
0.968
0.966
0.964
0.962
0.96
0.958
OCT21
SEP21
AUG21
JUL21
JUN21
MAY21
APR21
MAR21
FEB21
JAN21
DEC20
NOV20
KWH
KVAH
PF


Actual Demand Vs Billed Demand
140
120
100
80
60
40
20
0
OCT21
SEP21
AUG21
JUL21
JUN21
MAY21
APR21
MAR21
FEB21
JAN21
DEC20
NOV20
Actual KVA
Billed KVA


TOD Vs Energy Consumption
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
25000
20000
15000
10000
5000
0
OCT21
SEP21
AUG21
JUL21
JUN21
MAY21
APR21
MAR21
FEB21
JAN21
DEC20
NOV20
Energy
TOD

HVAC- Air Conditioning Systems

Introduction of Air Conditioning & Refrigeration System:

The present Air conditioning systems in the college are of Package Units , Split Air Conditioning units of star rated . The Air conditioning is analyzed for energy saving opportunities . The detailed measurements are taken on sample basis at some of the locations .

The Measurements of sample Split AC units are done in blocks and tabulated below

	Split Air Conditioners 2021-22											
Sl. No	Location	No. of A.C. Unit	Type of A.C.	Rated TR	Power kw	Inlet Temp.(°c)	Outlet Temp.(°c)	Flow m/sec	Arrived TR	Specific Power KW/TR	COP	EER
1	Old Block	1	Split AC	1.5	1.152	25.4	23.1	0.45	1.30	0.89	3.97	13.57
2	Old Block	1	Split AC	1.5	1.225	23.7	22.3	0.75	1.32	0.93	3.79	12.93
3	Old Block	1	Split AC	1.5	1.35	25.4	23.1	0.45	1.30	1.04	3.39	11.57
4	Old Block	1	Split AC	1.5	1.375	23.2	22.3	0.83	0.94	1.46	2.40	8.20
5	Old Block	1	Split AC	1.5	1.65	24.3	22.8	0.63	1.19	1.39	2.53	8.64
6	Old Block	1	Split AC	1.5	1.525	26.9	23.2	0.33	1.53	0.99	3.54	12.08
7	Old Block	1	Split AC	1.5	1.45	27.2	24.1	0.35	1.36	1.06	3.31	11.29

Energy Efficiency Opportunities

Reduce heat loads

Any reduction in heat loads results in a reduction in required refrigeration capacity and therefore energy consumption. There are three main methods for reducing heat loads:

· Improving insulation.

· Reducing air leakage.

·Reducing incidental and auxiliary gains.

Insulation improvements

The walls of a refrigerated space should be well maintained to guard against damage or degradation of the insulating material.

visual inspection will give first indications of problems while thermographic inspection will show up cold areas where insulation is poor.

- Air leakage

Air can leak through the degraded fabric of an enclosure or through an access such as a door. Taking the steps outlined above should prevent fabric leakage, while reducing air leakage through doors is outlined below:

Reduce temperature lifts

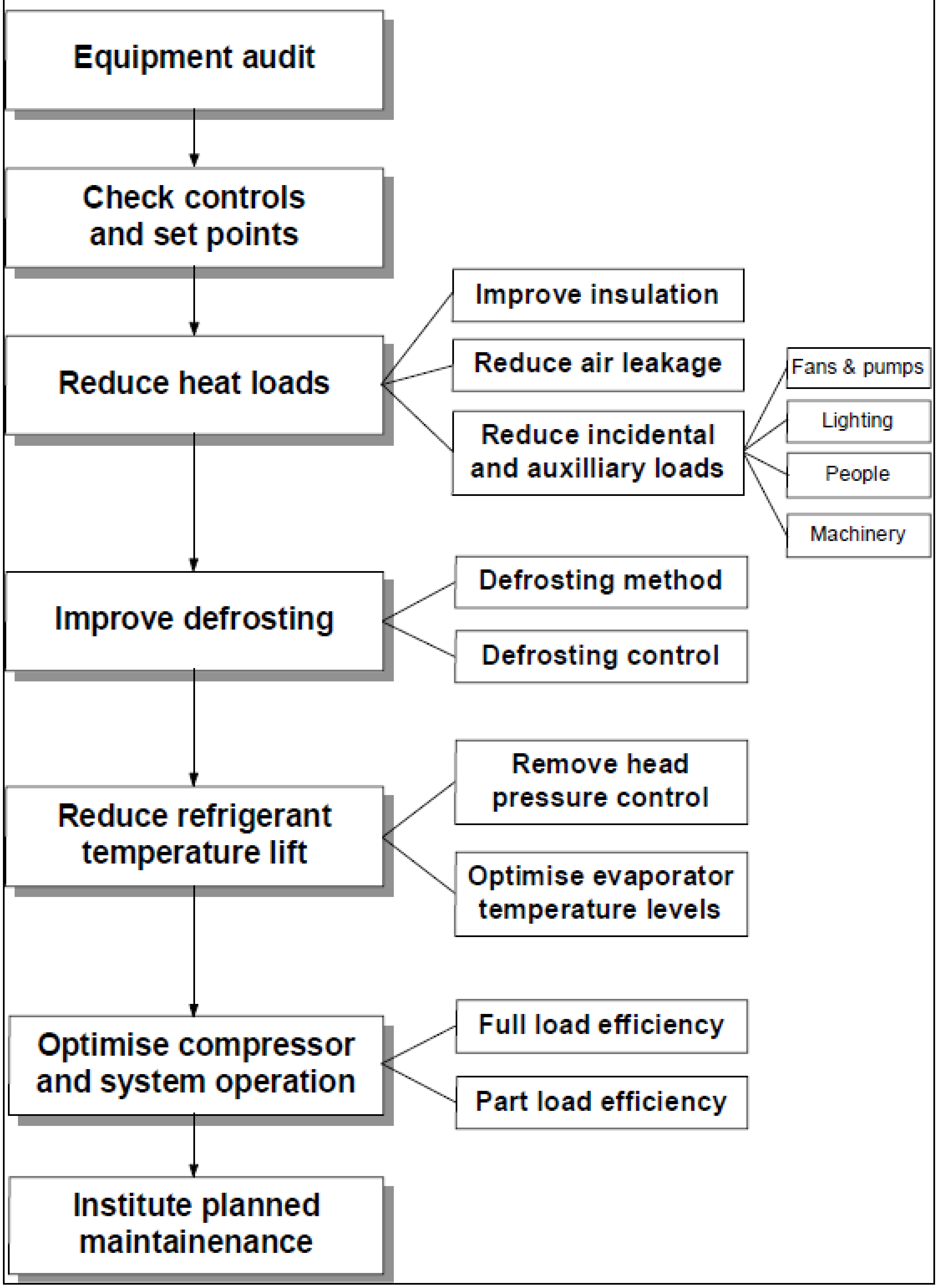
The efficiency of refrigerating plant is dependent upon the size of the temperature lift between the evaporator and the condenser: the smaller the lift the more efficient the system.

- Head pressure control

Many systems maintain a higher lift than is necessary through the use of head pressure control. This practice aims to maintain ahigh pressure in the condenser to ensure a controlled supply of refrigerant to the evaporator. The control pressure can be reduced using a balanced port thermostatic expansion valve or an electronic expansion valve, while the installation of a liquid line pump can further reduce the need for such control. Lowering the control pressure allows the condensing pressure to fall as the outside temperature falls from the design condition and can improve energy efficiency by 50%, particularly during winter. The cost of these measures varies between Rs. 15,000/- to Rs. 1,50,000/- if installed at the time of refrigerant replacement and will normally pay back in about two years.

The Package Units measurements are carried out on sample basis at various locations and following are the details tabulated calculating the SPC (Specific Power Consumption) , EER(Energy Efficiency Ratio), COP(Coefficient of Performance) .

Figure 1: Optimising energy efficiency



Maintenance & Electrical Safety

1. **Electrical Single Line Diagram / Lay Out Diagram / Equipment Layout / Electrical Control diagram**
   i. Check for Unauthorized Temporary Installations
   ii. Modification to be Updated
   iii. SLD reflects the actual installation
   iv. Duly approved by statutory authorities

2. **Importance of Electrical Safety in the Overall Safety System**

   Periodicity of comprehensive Electrical Safety check

   i. Understanding of electrical hazards
   ii. Electrical checkpoints in the safety checklist
   iii. Implementation priority for electrical hazards
   iv. Electrical Work Permit System
   v. Safe Electrical Operating Procedures

3 **Electrical Preventive Maintenance**

   i. Is there an Electrical Preventive Maintenance programme in place
   ii. Is the programme implemented? What is the slippage?
   iii. Are the relevant standards (statutes and non-statutory) referred and incorporated in the EPM programme?
   iv. Electrical Tests, Records, Test Procedure and periodicity (earth resistance, insulation resistance tests)
   v. Is the EPM programme only documented?
   vi. Transformer tests (dielectric strength, acidity, sludge deposits, dissolved gases, etc.) and periodicity
   vii. Periodic calibration of meters (ammeter, voltmeter, relays, temperature gauges) and test instruments (insulation resistance megger, earth resistance megger, multi-meters, etc.)

4 **Earthing System**
   i. Installation as per approved design?
   ii. Installation and Maintenance as per IS 3043?
   iii. Earth resistance measured periodically?
   iv. Test procedure
   v. Acceptable earth resistance values
   vi. Is the earthing system modified when electrical installation is modified?
   vii. Are neutral earth pits independent and separate?
   viii. Are earth pits identified?
   ix. Are two and distinct earth connections provided?
   x. Is the earth continuity tested?
   xi. Is bonding and earthing carried out to avoid ESD hazards?

Annexure I

Conversion factors

CONVERSION TABLES

1 Kcal	3.9685 Btu
1 KWh	3413 Btu
1 KWh	860 kcal
1 Btu	1.055 kJ
1 calorie	4.186 joules
1 hp	746 Watts
1 kg	2.2 Ib (pounds)
1 meters	3.28 feet
1 inch	2.54 cm
1 kg/cm^2	14.22 psi
1 atmosphere	1.0332 kg/cm^2
1 kg/cm^2	10 meters of water column @ 4 °C
1 kg/cm^2	9.807 × 10 4 passels
1 Ton of Refrigeration	3023 kcal/hour
1 Ton of Refrigeration	12000 Btu/hour
1 US Gallon	3.785 liters
1 imperial Gallon	4.546 liters
°F	1.8 × °C + 32
°k	°c + 273

Annexure -II -Abbreviations &Definitions

Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
Btu	British thermal unit
Btu/ft^2	British thermal units per square foot
J/m^2	Joules per square meter
kVA	kilovolt-amperes
kW	kilowatts
kWh	kilowatt-hours
kWh/m^2	kilowatt-hours per square meter

Definitions:

Basic definitions of terms

Absorber. The component of the vapour absorption chilling package wherein the refrigerant vapour is absorbed by the liquid absorbent.

Air Handling Unit. An air cooling unit, consisting of a blower or blowers, heat exchanger and filters with refrigerant, chilled water or brine on the tube side to perform one or more of the functions of circulating, cooling, cleaning, humidifying, dehumidifying and mixing of air.

Brine. Solution of anti-freeze substances like Sodium Chloride, Calcium Chloride, Mono-ethylene Glycol, Ethyl Alcohol etc.

Coefficient of Performance. The ratio of Net Refrigerating Effect divided by Compressor Shaft Power or Thermal Power Input. The numerator and denominator should be in the same measuring units.

Compressors. Machines in which compression of refrigerant vapour is effected by the positive action of linear motion of pistons, rotating elements (screws, vanes, scrolls etc.) or conversion of velocity energy to pressure in a centrifugal device.

Compressor, hermetic. Sealed compressor & motor unit, where the electric motor is cooled by the refrigerant and both the compressor and electric motor are not accessible for maintenance.

Compressor, open. Compressor is externally coupled to the prime mover and the refrigerant does not cool the prime mover.

Compressor, semi-hermetic. Compressor motor unit, where the electric motor is cooled by the refrigerant and the compressor is accessible for maintenance.

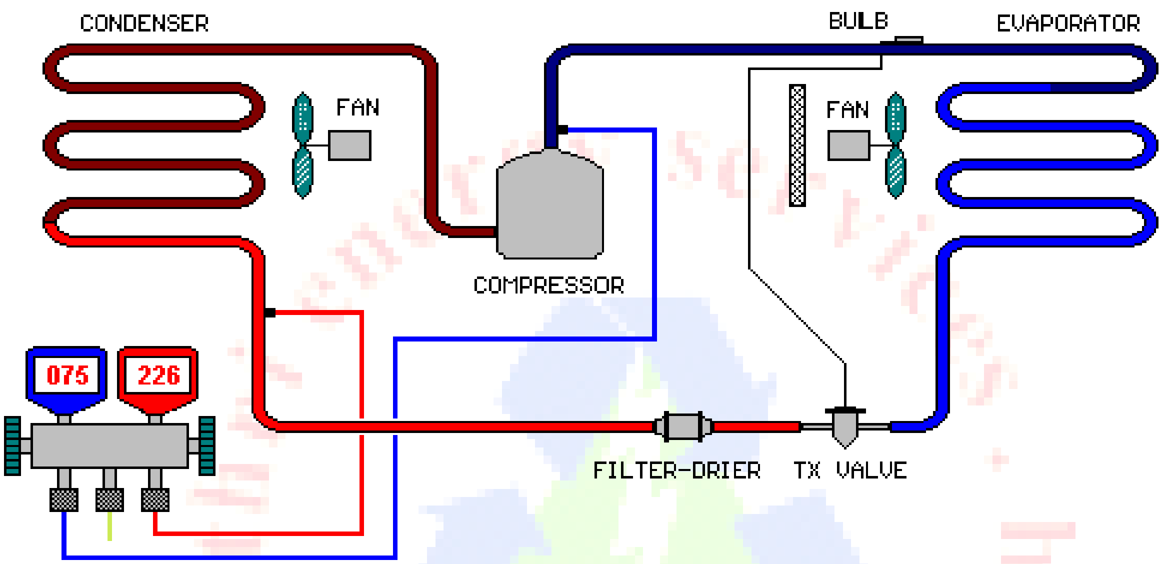
Condenser. The heat exchanger, which utilizes refrigerant to water/air heat transfer, causing the refrigerant to condense and the water/air to be heated. De-superheating or sub-cooling of the refrigerant may also occur.

Energy Efficiency Ratio. The ratio of Net Refrigerating Effect (Btu/hr) divided by Shaft Power (Watts) or Thermal Power Input (Watts) consumed.
Electric Motor. Electrically operated rotary prime mover.
Enthalpy. The heat content of a substance at a particular temperature.
Engine. Internal combustion engine used as prime mover.
Evaporator. The heat exchanger wherein the refrigerant evaporates and, in the process, cools another fluid I(generally water, brine or air).
Fluid. The substance that is usefully cooled in the chilling package (generally water, brine or air).
Generator. The component of a vapor absorption chilling package wherein the absorbent solution is heated to evaporate the refrigerant and concentrate the absorbent.
Gross Calorific Value. The amount of heat produced per unit of fuel when complete combustion takes place at constant pressure, the products of combustion are cooled to the initial temperature of the fuel and air, and the vapor formed during combustion is condensed.
Net Refrigeration Effect. The useful cooling effect (or heat removal) in the evaporator.
Psychometric Chart. A chart or plotted curves showing the various parameters of air at different temperatures at atmospheric pressure. The parameters shown include dry bulb temperature, wet bulb temperature, relative humidity, moisture content, enthalpy and sensible heat factor.
Refrigerant. The substance that evaporates in the evaporator to provide cooling effect.
Shaft Power. Power at the shaft of any rotary equipment.
Specific Fuel Consumption. The ratio of Thermal Power Input (kg/h of liquid fuel or m3/h of gaseous fuel consumed to the Net Refrigerating Effect (Tons of Refrigeration).
Specific humidity. Mass of water vapor per unit mass of dry air.
Specific Power Consumption. The ratio of Shaft Power (kW) to the Net Refrigerating Effect (Tons of Refrigeration).
Specific Steam Consumption. The ratio of Thermal Power Input (kg/h of steam) to the Net Refrigerating Effect (Tons of Refrigeration).
Speed. The number of revolutions per minute of the shaft.
Temperature, dry bulb. The temperature indicated by any temperature sensing element when held in air.
Temperature, Inlet. Temperature measured at the inlet stream of the heat exchanger.
Temperature, Outlet. Temperature measured at the outlet stream of the heat exchanger

Annexure :3 HVAC

Introduction & back ground

Refrigeration Basics



- Refrigeration is the removal of heat from a material or space, so that it's temperature is lower than that of its surroundings.
- When refrigerant absorbs the unwanted heat, this raises the refrigerant's temperature ("Saturation Temperature") so that it changes from a liquid to a gas — it evaporates. The system then uses condensation to release the heat and change the refrigerant back into a liquid. This is called "Latent Heat".
- This cycle is based on the physical principle, that a liquid extracts heat from the surrounding area as it expands (boils) into a gas.
- To accomplish this, the refrigerant is pumped through a closed looped pipe system.
- The closed looped pipe system stops the refrigerant from becoming contaminated and controls its stream. The refrigerant will be both a vapor and a liquid in the loop.

Annexure - 4 Lighting

Recommended illumination Levels as Per IS 3646 Part I-1992			
Type of Interior Activity	Range of Service Illuminanace in Lux	Quality Class of Direct Glare Limitation	Remarks
Education			
Assembly Halls	200-300-500	3	
Teaching Spaces	200-300-500	1	
Lecture Theatres			
i) General	200-300-500	1	
ii) Demo Benches	300-500-700	1	Localized Lighting may be appropriate
iii) Seminar Rooms	300-500-750	1	
iv) Art Rooms	300-500-750	1	
v) laboratories	300-500-750	1	
vi) Libraries	200-300-500	1	
vii)Music Rooms	200-300-500	1	
viii) Sports Hall	200-300-500	1	
ix) Work Shop	200-300-500	1	
x)Computer Work station	300-500-750	1	
xi)Bath Rooms	50-100-150		Supplementary local lighting near mirror
xii) Office Rooms	300-500-750	1	
xiii) Entrance Halls, Lobbies	150-200-300	2	
xiv) Corridors, Passageway, Stairs	50-100-150	2	

Light Source Comparison			
Attributes	**Incandescent**	**CFL**	**LED**
Colur Rendering Index	100	Greater than 80	40-80
Watts/ Lamp	100	23	1
Lumen/Lamp	1600	1600	30
Lumen/Watt	16	60-80	20-30
Life (Hrs)	750	8000	50,000

Colour Rendering Index

1500 K	Candlelight
2680 K	40 W incandescent lamp
3000 K	200 W incandescent lamp
3200 K	Sunrise/sunset
3400 K	Tungsten lamp
3400 K	1 hour from dusk/dawn
5000-4500 K	Xenon lamp/light arc
5500 K	Sunny daylight around noon
5500-5600 K	Electronic photo flash
6500-7500 K	Overcast sky
9000-12000 K	Blue sky