DETAILED ENERGY AUDIT REPORT

Year 2020-21

Prepared for

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Jijamata College of Science and Arts,

Dnyaneshwarnagar, Bhende Bk, Tal Newasa, Dist Ahmednagar

Prepared by

HITECH ENERGY SERVICES

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Abbreviations

Abbreviations	Full Form
°C	Degree Centigrade
A	Ampere
AC	Alternating Current
Avg.	Average
CFM	Cubic Feet per Minute
CMH	Cubic Meter per Hour
DB	Distribution Board
DG	Diesel Generator
Dia.	Diameter
hr.	Hour
I	Current
kCal	Kilo Calories
Kg.	Kilogram
kVA	Kilo Volt Ampere
kVAr	Kilo Volt Ampere Reactive
kW	Kilo Watts
kWh	Kilo Watt Hour
M or m	Meter
Max.	Maximum
M/c	Machine
MD	Maximum Demand
Min.	Minimum
SES	SES Energy Services Ltd.
Mm	Millimetre
MTs	Metric Tons
No.	Number
p.a.	Per Annum
PF	Power Factor
Sec.	Second
SEC	Specific Energy Consumption
THD	Total Harmonics Distortion
TPA	Tons per Annum
TPD	Tons per day
Temp.	Temperature
V	Voltage
VFD	Variable Frequency Drive
JCSA	Jijamata College Of Science And Arts
PEA	Pioneer Energy Auditor
yr.	Year

HIGHLIGHTS OF THE REPORT

A. JIJAMATA COLLEGE OF SCIENCE AND ARTS

- Year of Energy Audit : 2020-21
- Location : Dnyaneshwarnagar, Bhende Bk, Tal Newasa, Dist Ahmednagar

B. Energy Scene

- Energy source : MSEDCL
- Total annual electricity bill : RS. 13.90 lakh (Jun 20 - May 21)
- Major connected load : Computers, Lighting, Fan,

C. Key Result Areas for Energy Savings & Estimated Potential along with Broad Cost Benefit:

Sr. No.	Energy Saving Areas	Estimated Investment (Rs. Lakhs)	Estimated Energy Saving Potential (Rs.)	Simple Payback Period (Months)	Remark
1	Electricity Bill Analysis	0.027	0.311	1.0	Short term
2	Replacement of 20 Watt FTL with New 15 Watt Led Tube Light	1.35	0.451	36.0	Long term
3	Solar PV System for Fan and Computer	22.5	9.89	27.3	Long Term
4	Replacement of Old AC with New Inverter Air Conditioner AC	0.35	0.423	9.9	Short Term
5	Replacement of Fan with New Energy Efficient Fan	4.56	2.91	18.8	Mid Term
	Total	**28.78**	**13.98**	**24.0**	**--**

Payback period =Investment /revenues x 12 Months

ACKNOWLEDGEMENTS

An energy audit study is a joint venture exercise of consultant and industry to account & contain energy usage without sacrificing the purpose of energy use. The contribution of industry team is equally important in this venture. Team of technical experts of M/s. Hitech Energy Services, Pune appreciates the keen interest shown by the management of M/s.Jijamata College of Science and Arts. for their kind co-operation, furnishing required data, analysis reports and hospitality offered during our visits.

Dr. Saswade Ramkisan Raghunath	:	Hon.Principle
Dr. Navgire Madhukar Eknath	:	Coordinator/ IQAC
Dr. Lande Kakasaheb Abasaheb	:	Member
Prof. Naik Dhirsing wahrya	:	Member
Prof. Ghare Pravin Devram	:	Member
Dr. Gedam Ajit Kashinath	:	Member
Prof. Nawale Rohan Vijaykumar	:	Member
Shri. Gaikwad Dattatraya Bhausaheb	:	Member

We are also thankful to the other staff members who were actively involved while collecting operating data and conducting the field studies.

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Chapter 1

INTRODUCTION

1.1 Preamble

- M/s.Jijamata College of Science and Arts., Bhende having 58 KVA Contract demand and 53 KVA is maximum peak in the Jun 2020.
- This energy audit report for JCSA presents the analysis of the data collected, observations made and field trials undertaken. It is governed by the objectives, scope of work, and methodology discussed in ensuing paragraphs.

1.2 Objectives

- To undertake an energy audit at JCSA so as to identify areas for energy saving, both without and with investment.
- To prioritize distinct areas identified for energy savings depending upon saving potential, skills, and time frame for execution, investment cost, paybacks etc.

1.3 Methodology

- Pioneer Energy Auditor deputed following team of experts for conducting the study and worked in close association with JCSA personnel.

➢ Mr. Pradeep Thakur (Certified Energy Auditor)

➢ Hitech Energy Services submitted an execution work plan for the assignment for which client provided relevant data support.

- Client nominated specific persons from engineering / maintenance sections along with a co-ordinator of senior managerial level for this audit.
- HES undertook an "Orientation Meeting" with management / engineering / maintenance personnel prior to start of the audit.
- HES's team conducted all necessary field trials and measurements.
- HES provided all the instruments necessary for conducting the field trials.
- HES's team used following instruments;

Table 1: Instruments Used by Energy Audit Team

Sr. No.	Instrument Name	Specification
1.	Power Analyzer	Suitable for 1φ, 3φ. 156 electrical parameters like voltage, current, frequency, harmonics, active & reactive power, power factor etc.
2.	Clamp-on Power Meter	0 - 1200 kW 0 - 600 Voltage, AC 0 - 800 Voltage, DC 0 - 2000 A, Current, AC / DC
3.	Lux Meter	0 - 50,000 lux level Non Contact Type
4.	Digital Thermo Anemometer	0 - 45 m / sec. ± 3%
5.	Relative Humidity and Temperature Indicator	RH – 10% to 95% Temp. – 0 – 100 °C Handheld unit
7.	Infrared Thermometers	40 ^{0}C to 500 ^{0}C
8.	Portable Temperature Indicator	50 ^{0}C to 1200 ^{0}C

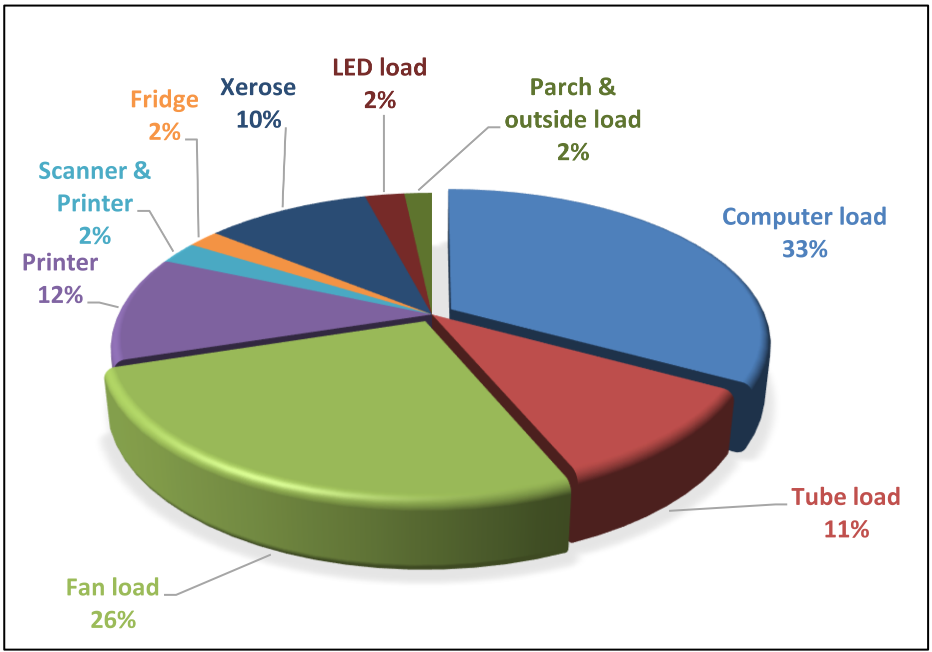
Chapter 2

BACK DROP ON ENERGY SCENE

2 Electrical Energy Share

- The primary source of electrical power for the bank is from the MSEDCL Grid with contract demand of 58 KVA.
- Major electrical energy consumers at the bank have been shown in below figure. As can be noted the water heaters, air conditioners, celling fan, Lighting The study involved analysis the actual major consumers followed by energy saving opportunities at these sections.

Figure 1:Various Loads Contribution in %



- Average Grid contract demand is 58 kVA.
- Average registered actual demand is 41 KVA with a maximum peak of 53 KVA.
- The below table indicates average consumption for the reference period.

Table 2 : Electricity consumption Details

Months	RS/Months	kWH	KVA
Jun-20	180703	12853	53
Jul-20	91601	6230	40
Aug-20	93073	6348	40
Sep-20	102321	7094	40
Oct-20	116803	8443	40
Nov-20	92178	6276	40
Dec-20	97597	6686	40
Jan-21	109326	7624	40
Feb-21	114603	8084	40
Mar-21	127412	9026	40
Apr-21	129172.18	9536	40
May-21	135439.28	10145	40
AVG	**115852.37**	**8195**	**41**
Total	**1390228.46**	**98345**	**--**

2.1 Energy Metering, Monitoring & Control System - Existing Status

2.2 Electricity

- Electrical energy consumption at the facility is measured on the main meter on daily basis.
- Adequate instrumentation is observed for power, voltage & current.

2.3 Level of Awareness

- The level of awareness for energy conservation in top & middle management is excellent. It has however felt necessary to make serious efforts to percolate the same up to the individual operating personnel level.

2.3.1 Power Measurement Survey

Table 3: Power Survey

Mode	Phase	V	A	KW	P.F
1 Phase	R-N	235	25	4.8	0.82
	Y-N	237	30	6.3	0.88
	B-N	237	19	3.8	0.84
3 Phase	RY	419	22	14.0	0.88
	YB	422	24	14.4	0.82
	BR	421	23	14.3	0.85

Observation:

Table 3: Voltage observations at MSEDCL Incomer

Voltage	Avg.	Max	Min	% Unbalance	Remark
V1	419	435	415	0.97	☑ Pass
V2	422	434	420	0.98	☑ Pass
V3	421	439	425	0.98	☑ Pass

Suggestion:

- Voltage % Unbalance are found within the specified limit
- Specified Limit is 1% as per the NEC 2019

Observation:

Table 4: Current Observations at Main incomer

Current	Avg.	Max	Min	% Unbalance	Remark
I1	22	23	21	0.89	☑ Pass
I2	24	25	23	0.89	☑ Pass
I3	23	25	20	0.91	☑ Pass

Observations:

- Current % Unbalance are found within the specified limit of 10%

• 2.3.4 Exisisting Connected Load in kW

Table 5 – Exisisting Connected Load 2020-21

Types of Load	Qty	Watt per unit	Watt	KW	Load %
Computer load	95	180	17100	17.1	33%
Tube load	270	20	5400	5.5	11%
Fan load	228	60	13680	13.68	26%
Printer	27	220	5940	5.94	11%
Scanner & Printer	5	250	1250	1.25	2%
Fridge	5	200	1000	1	2%
Xerose	5	1040	5200	5.2	10%
LED load	120	10	1200	1.24	2%
Parch & outside load	36	24	864	0.864	2%
Total	**791**	**2004**	**51634**	**51.774**	**100%**

Chapter 3

ENERGY CONSERVATION OPPORTUNITIES

3.0 Electricity Bill Analysis

Sr. No.	Month	Contract Demand (KVA)	Actual Demand (KVA)	Units Consumed (KVAH/kWh	Power Factor	Total Bill (Rs.)	Charges for Excess Demand (Rs.)	Billing \ MSEB load factor (%)	Plant load factor (%)	Rs/kWh
1	Jun-20	58	53	12853	0.85	180703	0	36.2	39.6	14.06
2	Jul-20	58	40	6230	0.89	91601	0	16.8	24.3	14.70
3	Aug-20	58	40	6348	0.88	93073	0	17.3	25.0	14.66
4	Sep-20	58	40	7094	0.83	102321	0	20.5	29.7	14.42
5	Oct-20	58	40	8443	0.86	116803	0	23.5	34.1	13.83
6	Nov-20	58	40	6276	0.89	92178	0	16.9	24.5	14.69
7	Dec-20	58	40	6686	0.86	97597	0	18.6	27.0	14.60
8	Jan-21	58	40	7624	0.88	109326	0	20.7	30.1	14.34
9	Feb-21	58	40	8084	0.82	114603	0	23.6	34.2	14.18
10	Mar-21	58	40	9026	0.959	127412	0	22.5	32.7	14.12
11	Apr-21	58	40	9536	0.839	129172.18	0	27.2	39.5	13.55
12	May-21	58	40	10145	0.823	135439.28	0	29.5	42.8	13.35
		58	**41**	**8195**	**0.865**	**115852.37**	--	**22.78**	**31.96**	**14.21**
		--	--	**98345**		**1390228.46**	**0**	--	--	--

Electricity Bill Analysis Calculations

Average P.F: 0.86

Desired P.F: 0.99

Kw Drawn = 41 KVA x0.86 = 35.26

KVAr required = 35.26 (Tanø1-Tanø2)

= 35.26 (0.593 - 0.142)

= 35.26 x (0.451)

= 15.90 ~ 15 kVAr

Reduction in Demand = 41 – 35 = 6 KVA/Month

Reduction in Demand charges: 6 KVA *12 Months*RS 432 /KVA = Rs 31104 / Year

Total Revenue possible in RS = 31104

Investment in RS = 2700

Payback Period = 32 Days

3.1 Replacement of 20 Watt Tube Light With 15 W LED Tube Light

Table 6 : Saving Potential with 15 Watt LED

Sr. No.	Lighting Description	Actual Consumption	Estimated Saving Potential with 15 W LED Tuble Light
1	**FTL Light 270 Qty ------ 20 W each**	**5.4 kW**	**4.0 kW**
	Total kWh Saving	**---**	**1.4 kWh**
	Electricity cost per Rs/kWh	**9.21**	**Rs/kWh**
	Annual operating Hr	**3500 hr**	
	Saving potential per year = 1.4 x 3500 x 9.21 = Rs 45129 per Year **Imvestment Cost For 270 Fittings = 1.35 Lakh** **Simple Payback period is = 3 Year**		

Specifications: 15 LED Tube Light:

Power	15 W
Input Voltage	90-280V AC
LED	Philips/Cree/Osram
Color	Warm White/ Pure White
C.C.T.	2700-3300K(WW)/5500-6500K(PW)
Efficiency	>85%
Power factor	>0.90
Lumens"	100 lumen per watt
Life Span	>50000 hours
CRI	>80%
Replacement for	20 w FTL
Length	T5 1200 MM

3.2 Installation of Solar Photo Voltic Project for Fan & Computers

Table 7: Installation of Rooftop solar Photovoltaic system

Sr. No.	Description	Actual Consumption	Estimated Saving Potential with Solar P. V
1	Computer Load	17.1 kW	17.1 kW
2	Celling Fan	13.6 KW	13.6 kW
	Total kWh Saving	30.7	30.7 kWh
	Electricity cost per Rs/kWh	9.21	Rs/kWh
	Annual operating Hr	3500	Hr
	Saving potential per year = 30.7 x 3500 x 9.21 = 9.89 Lakh Capital Investment for Solar PV Projects : 22.5 Lakh (Proposed 50 KW Solar projects) Simple payback Period is = 2.27 Year		

Figure 2 : Rooftop Solar Photovoltaic system

3.3 Installation of Inverter AC instead of Normal AC

Figure 3:Advantages of Inverter Air Conditioner

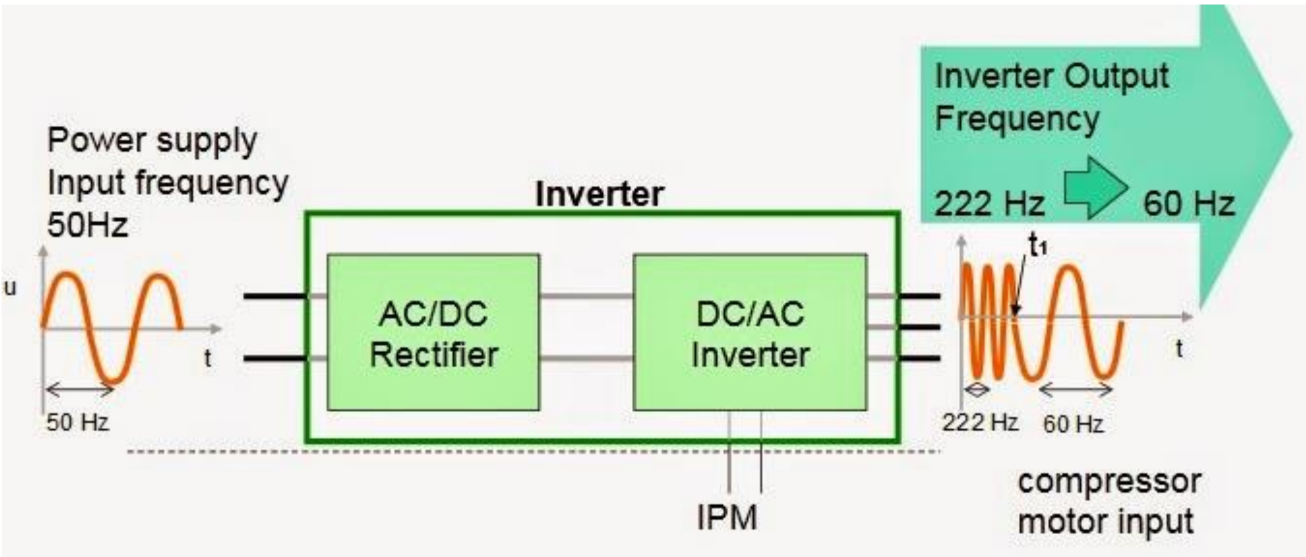


Table 8: Saving potential with Inverter AC

Sr. No.	Air Conditioner	Actual Consumption	Estimated Saving Potential with Inverter AC
1	1 X 1 TR AC – Daily 8 Hr. Operation 1 TR = 3.5 kW	3.5 kW	2.45 kW
	Total kWh Saving	-	1.05 kWh
	Electricity cost per Rs/kWh	9.21	Rs/kWh
	Annual operating Hr	4380	Hr
	Saving potential per year = 1.05 x 4380 x 9.21 = Rs 42356 Capital Investement for New Inverter AC = Rs 35000 Simple payback period is = 301 days		

3.4 Installation of Energy Efficient Fan with Existing Fan

Table 9: Saving Potential with Celling Fan

Sr. No.	Description	Actual Consumption	Estimated Saving Potential with 5 Star Energy Efficient Celling Fan (30 Watt)
1	Celling Fan 228 Qty ------ 60 W each	13.6 kW	6.8 kW
	Total kWh Saving	---	6.8 kWh
	Electricity cost per Rs/kWh	9.21	Rs/kWh
	Annual operating Hr	3500 hr	Hr
	Saving potential per year = 6.8 x 3500 x 9.21 = 2.91 Investement for energy efficient Fan = 4.56 Lakh Simple Payback period is = 1.56 Year		

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Chapter - 4

ENERGY CONSERVATION:
GENERAL ENERGY CONSERVATION TIPS

General Energy Conservation Tips

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

Checklist & Tips For Energy Efficiency In Electrical Utilities

1.1.1 Electricity

- Optimise the tariff structure with utility supplier
- Schedule your operations to maintain a high load factor
- Minimise maximum demand by tripping loads through a demand controller
- Stagger star-up times for equipment with large starting currents to minimise 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

1.1.2 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^{0}C increase in motor operating temperature over recommended peak, the motor life is estimated to be halved)
- Check for under-voltage and over-voltage conditions.
- Balance the three-phase power supply. (An Imbalanced voltage can reduce 3 – 5% in motor input power)
- Demand efficiency restoration after motor rewinding. (If rewinding is not done properly, the efficiency can be reduced by 5 – 8%)

1.1.3 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.
- Use synthetic lubricants for large gearboxes.
- Eliminate eddy current couplings.
- Shut them off when not needed.

1.1.4 Fans

- Use smooth, well-rounded air inlet cones for fan air intakes.
- Avoid poor flow distribution at the fan inlet.
- Minimise fan inlet and outlet obstructions.
- Clean screens, filters and fan blades regularly.
- Use aerofoil-shaped fan blades.
- Minimise fan speed.
- Use low-slip or flat belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable fan loads.
- Use energy-efficient motors for continuous or near-continuous operation
- Eliminate leaks in ductwork.
- Minimise bends in ductwork.
- Turn fans off when not needed

1.1.5 Blowers

- Use smooth, well-rounded air inlet ducts or cones for air intakes.
- Minimise blower inlet and outlet obstructions.
- Clean screens and filters regularly.
- Minimise blower speed.
- Use low-slip or no-slip belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable blower loads.
- Use energy-efficient motors for continuous or near-continuous operation.
- Eliminate ductwork leaks.
- Turn blowers off when they are not needed

1.1.6 Pumps

- Operate pumping near best efficiency point.
- Modify pumping to minimise 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 minimise water waste.
- Balance the system to minimise flows and reduce pump power requirements.
- Use siphon effect to advantage: don't waste pumping head with a free-fall (gravity) return.

1.1.7 Compressors

- Consider variable speed drive for variable load on positive displacement compressors.
- Use a synthetic lubricant if the compressor manufacturer permits it.
- Be sure lubricating oil temperature is not too high (oil degradation and lowered viscosity) and not too low (condensation contamination).
- Change the oil filter regularly.
- Periodically inspect compressor intercoolers for proper functioning.

- Use water heat from a very large compressor to power an absorption chiller or preheat process or utility feeds.
- Establish a compressor efficiency-maintenance program. Start with an energy audit and follow-up, then make a compressor efficiency-maintenance program a part of your continuous energy management program.

1.1.8 Compressed Air

- Install a control system to co-ordinate multiple air compressors.
- Study part-load characteristic and cycling costs to determine the most-efficient mode for operating multiple air compressors.
- Avoid over sizing – match the connected load.
- 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 (8kg/cm² to 7 kg/cm²) would result in 9% input power savings. This will also reduce compressed air leakage rates by 10%)*
- 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 minimise heatless desiccant dryer purging.
- Minimise 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.
- Be sure that heat exchangers are not fouled (eg. – with oil)
- Be sure that air / oil separators are not fouled.
- Monitor pressure drops across suction and discharge filters and clean or replace filters promptly upon alarm.
- Use a properly sized compressed air storage receiver.
- Minimise disposal costs by using lubricant that is fully demulsible and an effective oil-water separator.
- Consider alternatives to compressed air such as blowers for cooling, hydraulic rather than air cylinders, electric rather than air actuators and electronic rather than 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.
- In dusty environments, control packaging lines with high-intensity photocell units instead of standard units with continuous air purging of lenses and reflectors.
- Establish a compressed air efficiency-maintenance program. Start with an energy audit and follow-up, then make a compressed air efficiency-maintenance program a part of your continuous energy management program.

1.1.9 Chiller

- Increase the chilled water temperature set point if possible.

- Use the lowest temperature condenser water available that the chiller can handle. *(Reducing condensing temperature by 5.5°C, results in a 20 – 25% decrease in compressor power consumption)*
- Increase the evaporator temperature *(5.5°C increase in evaporator temperature reduces compressor power consumption by 20 – 25%)*
- Clean heat exchangers when fouled. *(1 mm scale build-up on condenser tubes can increase energy consumption by 40%)*
- Replace old chillers or compressors with new higher efficiency models.
- Use water-cooled rather than air-cooled chiller condensers.
- Use energy-efficient motors for continuous or near continuous operation.
- Specify appropriate fouling factors for condensers.
- Do not overcharge oil.
- Install a control system to co-ordinate multiple chillers.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple chillers.
- Run the chillers with the lowest operating costs to near base load.
- Avoid oversizing – match the connected load.
- Isolate off-line chillers and cooling towers.
- Establish a chiller efficiency-maintenance program. Start with an energy audit and follow-up, then make a chiller efficiency-maintenance program a part of your continuous energy management program.

1.1.10 HVAC (Heating / Ventilation / Air Conditioning)

- 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 minimise 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 minimise HVAC equipment operating time.
- In winter during unoccupied periods, allow temperature to fall as low as possible without damaging stored materials.
- Improve control and utilisation 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).
- Optimise 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.
- Use evaporative cooling in dry climates.
- Reduce humidification or dehumidification during unoccupied periods.
- Use atomisation rather than steam for humidification where possible.
- Clean HVAC unit coils periodically and comb mashed fins.
- Upgrade filter banks to reduce pressure drop and thus lower fan power requirements.
- Check HVAC filters on a schedule (at least monthly) and clean / change if appropriate.
- Check pneumatic controls air compressors for proper operation, cycling, and maintenance.

- Isolate air conditioned loading dock areas and cool storage areas using high-speed doors or clear PVC strip curtains.
- Install ceiling fans to minimise thermal stratification in high-bay areas.
- Relocate air diffusers to optimum heights in areas with high ceilings.
- Consider reducing ceiling heights.
- Eliminate obstructions in front of radiators, baseboard heaters, etc.
- Check reflectors on infrared heaters for cleanliness and proper beam direction.
- Use professionally-designed industrial ventilation hoods for dust and vapour control.
- Use local infrared heat for personnel rather than heating the entire area.
- Use spot cooling and heating (e.g. – use ceiling fans for personnel rather than cooling the entire area).
- Purchase only high-efficiency models for HVAC window units.
- Put HVAC window units on timer control.
- Do not oversize cooling unit. (Oversized units will "short cycle" which results in poor humidity control.)
- Install multi-fuelling capability and run with the cheapest fuel available at the time.
- Consider dedicated make-up air for exhaust hoods. (Why exhaust the air conditioning or heat if you do not need to?)
- Minimise HVAC fan speeds.
- Consider desiccant drying of outside air to reduce cooling requirements in humid climates.
- Consider ground source heat pumps.
- Seal leaky HVAC ductwork.
- Seal all leaks around coils.
- Repair loose or damaged flexible connections (including those under air handling units).
- Eliminate simultaneous heating and cooling during yearal transition periods.
- Zone HVAC air and water systems to minimise energy use.
- Inspect, clean, lubricate and adjust damper blades and linkages.
- Establish and HVAC efficiency-maintenance program. Start with an energy audit and follow-up, then make an HVAC efficiency-maintenance program a part of your continuous energy management program.

1.1.11 Refrigeration

- Use water-cooled condensers rather than air-cooled condensers.
- Challenge the need for refrigeration, particularly for old batch processes.
- Avoid oversizing – match the connected load.
- Consider gas-powered refrigeration equipment to minimise 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.
- Do not 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 minimise 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.
- Establish a refrigeration efficiency-maintenance program. Start with an energy audit and follow-up, then make a refrigeration efficiency-maintenance program part of your continuous energy management program.

1.1.12 Cooling Tower

- Control cooling tower fans based on leaving water temperatures.
- Control to the optimum water temperature as determined from cooling tower and chiller performance data.
- 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 minimise 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, PVC cellular units.
- If possible, follow manufacturer's recommended clearances around cooling towers and relocate or modify structures, signs, fences, dumpsters, etc. that interfere with air intake or exhaust.
- Optimise cooling tower fan blade angle on a yearal 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.
- Optimise chemical use.
- Consider side stream water treatment.
- Restrict flows through large loads to design values.
- Shut off loads that are not in service.
- Take blowdown water from the return water header.
- Optimise blowdown water from the return water header.
- Automate blowdown to minimise it.
- Send blowdown to other uses (Remembers, the blowdown does not have to be removed at the cooling tower. It can be removed anywhere in the piping system.)
- Implement a cooling tower winterisation plan to minimise ice build-up.
- Install interlocks to prevent fan operation when there is no water flow.
- Establish a cooling tower efficiency-maintenance program. Start with an energy audit and follow-up, then make a cooling tower efficiency-maintenance program a part of your continuous energy management program.

1.1.13 Lighting

- 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 vapour, 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.
- Consider painting the walls a lighter colour and using less lighting fixtures or lower wattages.
- Use task lighting and reduce background illumination.
- Re-evaluate exterior lighting strategy, type and control. Control it aggressively.
- Change exit signs from incandescent to LED.

1.1.14 DG Set

- Optimise loading
- Use waste heat to generate steam / hot water / power an absorption chiller or preheat process or utility feeds.
- Use jacket and head cooling water for process needs.
- Clean air filters regularly.
- Insulate exhaust pipes to reduce DG set room temperatures.
- Use cheaper heavy fuel oil for capacities more than 1MW.

1.1.15 Building

- Seal exterior cracks / openings / gaps with caulk, gasketing, weather-stripping etc.
- Consider new thermal doors, thermal window, roofing insulation, etc.
- Install windbreaks near exterior doors.
- Replace single-pane glass with insulating glass.
- Consider covering some window and skylight areas with insulated wall panels inside the building.
- 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.
- Add vestibules or revolving doors to primary exterior personnel doors.
- 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 minimise 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 minimise lighting and HVAC costs.

1.1.16 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 minimise 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 water leaks.
- Test for underground water leaks. (It is easy to do over a holiday shutdown.)
- Check water overflow pipes for proper operating level.
- Automate blow down to minimise it.
- 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 year – install a smaller, more-efficient system for the cooling year service hot water.
- If water must be heated electrically, consider accumulation in a large insulated storage tank to minimise heating at on-peak electric rates.
- Use multiple, distributed, small water heaters to minimise thermal losses in large piping systems.
- Use freeze protection valves rather than manual bleeding of lines.
- 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.

1.1.17 Miscellaneous

- Meter any unmetered utilities. Know what is normal efficient use.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 neighbours, 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 minimise undesirable heat transfer in long pipelines.
- Minimise use of flow bypasses and minimise 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.

1.2 Checklist & Tips For Energy Efficiency In Thermal Utilities

1.2.1 Insulation

- Repair damaged insulation
- Insulate any hot or cold metal or insulation
- Replace wet insulation
- Use an infrared gun to check for cold wall areas during cold weather or hot wall areas during hot weather
- Ensure that all insulated surfaces are cladded with aluminium.
- Insulate all flanges, valves and couplings.
- Insulate open tanks.

1.2.2 Waste Heat Recovery

- Recover heat from flue gas, engine cooling water, engine exhaust, low pressure waste steam, drying oven exhaust, boiler blowdown, etc.
- Recover heat from incinerator off-gas.
- Use waste heat for fuel oil heating, boiler feed water heating, outside air heating etc.
- Use chiller waste heat to preheat hot water.
- Use heat pumps.
- Use absorption refrigeration.
- Use thermal wheels, run-around systems, heat pipe systems and air-to-air exchangers.

SITE IMAGE GALLERY