KALINGA UNIVERSITY

RAIPUR|INDIA

Village Kotni near Mantralaya, Naya Raipur, 492101 (CG) India

ENERGY AUDIT MANUAL

Table of Contents

Introduction

Kalinga University is committed to sustainability and seeks to enhance energy efficiency in its operations. An energy audit manual serves as a guide for conducting systematic evaluations of energy usage within a university campus or any large institution. It can be practically utilized as:

1. Training Resource: The manual can be used as a training resource for the energy audit team. New members can refer to it to understand the audit process, their roles, and responsibilities.
2. Standard Operating Procedure (SOP): It establishes a standardized procedure for conducting energy audits across different departments or buildings within the university. This ensures consistency and reliability in audit results.
3. Data Collection Tool: The manual provides guidelines on data collection methods and the types of data to gather, such as utility bills, meter readings, and equipment specifications.
4. On-Site Assessment Guide: It offers a checklist or guide for conducting on-site inspections, helping auditors identify energy inefficiencies in various systems like HVAC, lighting, and building insulation.
5. Analysis Framework: The manual outlines how to analyze collected data, providing tools or software recommendations for data processing and analysis. It may also include benchmarks for comparison to gauge the university's energy performance.
6. Opportunity Identification: It helps auditors identify energy-saving opportunities based on audit findings, prioritizing them based on cost-effectiveness and potential savings.
7. Recommendation Generator: Based on audit findings, the manual suggests energy efficiency improvement recommendations, estimating costs and potential savings for each suggestion.
8. Implementation Plan Generator: It assists in developing a plan for implementing recommended measures, assigning responsibilities, setting timelines, and tracking progress.
9. Monitoring and Verification Protocol: The manual outlines procedures for monitoring energy usage post-implementation and verifying achieved savings, ensuring that energy efficiency measures are effective.
10. Reporting Format: It provides a template for preparing audit reports,

specifying the format, content, and intended audience for the reports.

11. Regulatory Compliance Guide: The manual ensures compliance with relevant energy efficiency regulations and standards, helping the university avoid penalties and fines.
12. Continuous Improvement Tool: By scheduling periodic reviews and updates, the manual facilitates continuous improvement in energy management practices, incorporating feedback from audits and adopting best practices.

About University

Kalinga University, Raipur has emerged as a Center of excellence of higher education in Central India. Strategically located in the Smart City of New Raipur, this University has started carving a niche for itself in the education domain andis rising as a shining star on the horizon of quality education.

Establishment - Established in 2013, this university has been able to win the confidence of over 7000 students. Meritorious students from all over the country and various foreign countries namely Afghanistan, Bangladesh, Nepal, Nigeria, South Korea and Uganda have chosen this University for their education and career.

Infrastructure – Kalinga boasts of World Class Infrastructure and student facilities with student centric approach. Highest attention is paid to hands on learning approach and students are encouraged to come up with innovative ideas for projects and practical. The University has more than 75 laboratories and workshops, all well equipped with the latest, state of the art apparatus andtools. Special emphasis is given to the development of communication skills through the language lab. More than 1200 computers are available for the use of the students.

The library has a collection of over 79,000+ books and offers Digital content through membership of DELNET, National Digital Library and NPTEL. Various magazines and journals are available for the use of the faculty and students.

Infrastructure consists of Student Hostel facilities, Green Acres, Canteen, Food Mess, Gymnasium, Fully Wi-Fi Campus, ATM, Mini Market, Student hangout Areas, Sports Complex, Re-creation Halls with Indoor Games and Music and recreation activities.

Objectives

- Assess and analyses energy usage across campus.
- Identify energy-intensive areas and equipment.
- Propose cost-effective energy-saving measures.
- Promote renewable energy integration.
- Air Conditioners and Fans shall be changes in Phased Manner.
- Regular (Daily) Monitoring of Power Factor shall be done.
- MDI is increasing in summer months. It shall be monitored to keep it less than contract demand (300KVA) to avoid penalty.
- Power Generation from Solar Plant shall be monitored monthly to evaluate solar performance for provision of additional Solar PV plant to save energy cost.
- Energy Meter to be installed in DGs to evaluate performance of Diesel Generators.
- Posters related to Energy conservation to be displayed in common areas for awareness of Students and University staff.
- University level events may be organized for exploration of new methods of Energy Conservation.

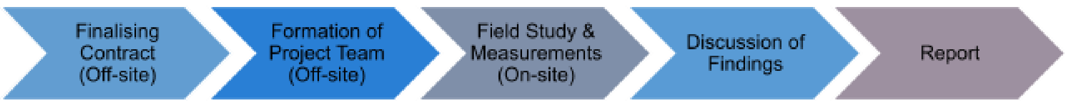
Approach & Methodology

- Identify areas of opportunity for energy saving and recommend an action plan to bring down total energy cost
- Conduct energy performance evaluation and process optimization study
- Conduct efficiency test of equipment and make recommendations for replacement (if required) by more efficient equipment with projected benefits
- Suggest improved operation & maintenance practices
- Provide details of investment for all the proposals for improvement
- Evaluate benefits that accrue through investment and payback period
- Analyze various energy conservation measures and to prioritize based on the maximum energy saving & investment i.e. short, medium and long term.

Prioritization	Payback Period
Short Term Project	Less than 6 months
Medium Term Project	Between 6 to 12 months
Long Term Project	More than 12 months

Methodology

The general methodology followed is captured in the following figure:



The study was conducted in 3 stages:

- Stage 1: Walk through audit to understand process energy drivers, measurability and formulation of audit plan.
- Stage 2: Detailed Energy audit.
- Stage 3: Off-site work for data analysis and report preparation

Instrument Used

The following portable instruments were used for data measurement: three phase Power Analyzer, Single phase Power Analyzer, Ultrasonic Water Flow Meter, Anemometer, Hygrometer, Sling Hygrometer, Digital Thermometer, Infrared Thermometer, Pressure gauge, Thermal Imager, Flue Gas Analyzer, Lux Meter

Observation and Analysis

Electricity Supply and Network

Electricity & fuel (Diesel) are major energy sources of the University. Electricity is supplied from CSPDCL (Chhattisgarh State Power Distribution Company Limited). Total Consumption of Electricity from Grid in the period of was

- Total KWH: 584020
- Electricity Charges: Rs. 62,11,323/-

The Diesel as a thermal energy source is used mainly in DG Sets of 2 X 250 KVA

- Total Consumption of Diesel in the Feb-22 to Jan-23 was
- Total Diesel in Liters – 22094
- Cost of Diesel: Rs. 20,58,497/-

Kalinga University has set up Solar Panels generating 300 KV (200 KV + 100 KV) of electricity, which is directly linked to the grid. Apart from the above, the university has 24 solar street lightings.

Electricity (INR)	Diesel (INR)	Total Cost of Energy	% of electricity	% of Diesel

Analysis of Electricity Bills

Kalinga University has two electrical connections with a total contract demand of 300 kVA. Power Supply is received from CSPDCL (Chhattisgarh State Power Distribution Company Limited). Monthly Electricity Billing has been studied for a period of one year. All parameters have been studied & tabulated in Table.

Sr. No.	Billing Month	No. of Days	Working Hours	Sanctioned Load, Kw/CD	Units Consumed, kWh	Units Consumed, kVAH	Solar Generated	Net Billed Units =	MDI	Average P.F.	Total Bill, Rs.
1	Feb-22	28	9	300	18705	19032	0	18705	80	0.98	209272
2	Mar-22	31	9	300	47781	48508	0	47781	203	0.99	497044
3	Apr-22	30	9	300	75436	76572	0	75436	242	0.99	765580
4	May-22	31	9	300	74812	76330	0	74812	263	0.98	747280
5	Jun-22	30	9	300	63106	64942	13.5	63106	273	0.97	676190
6	Jul-22	31	9	300	37431	38008	1099	37431	158	0.98	416570
7	Aug-22	31	9	300	47163	47743	847	47163	215	0.99	514474
8	Sep-22	30	9	300	66625	67050	52.5	66625	242	0.99	697730
9	Oct-22	31	9	300	62659	63174	0	62659	238	0.99	703723
10	Nov-22	30	9	300	35002	36417	2307	35002	154	0.96	433170
11	Dec-22	30	9	300	28090	28801	7263	28090	108	0.98	291958

12	Jan-23	30	9	300	27210	27684	7733	27210	117	0.98	258332
TOTAL					584020	594261	19315	584020	273	0.98	6211323

- Net Billed Unit in the Last 12 Month period
- Unit Consumed (KVAH)
- Power Factor Variation
- MDI
- Monthly Bill

Solar Power System

Kalinga University has set up Solar Panels generating 300 KV (200 KV + 100 KV) of electricity, which is directly linked to the grid. Apart from the above, the university has 24 solar street lightings.

Average Sunshine Data of Raipur

Month	Temperature	Average Sunshine (Hours)
January	28	11.4
February	32	11.6
March	36	11.8
April	40	12.34
May	47	12.97
June	37	12.93
July	31	6.04
August	30	5.9
September	31	10.91
October	31	11.45
November	29	11.21
December	27	11.4

Transformer

Kalinga University has two electrical connections. One HT with a total contract demand of 300 kVA. The other one is LT connection for two hostels. Power Supply is received from CSPDCL (Chhattisgarh State Power Distribution Company Limited) at 11 KV. Subsequently, the voltage is stepped down by one (1) Transformer of 300 kVA from 11 kV to 0.433 kV. Transformer rated specifications are shown below.

Transformer Rate Details

Sr. No.	Particulars	TR # 1
1	Make	Power Star
2	KVA	300
3	Volts at HV/LV	11000/433
4	Phases	3
5	Frequency	50

Transformer Load Survey

During the site visit, 24-hour log of Transformer (300 kVA) was made to record the load profile of Transformer, which includes the variations in the voltage, current, power factor, kW, kVA, Vthd, Ithd etc. Details of the load profile are provided in the below table and figure.

TR-1 300 KVA Load Measurement Data

Main Incomer LT Side		Transformer (300 kVA)
Particulars	**Phase**	**Average Measured Values**
Voltage (Volts) (L-L)	Phase "R"	410
	Phase "Y"	417
	Phase "B"	420
Current (Amps)	Phase "R"	63
	Phase "Y"	58
	Phase "B"	55
	Neutral	12
Load (KW)	Phase "R"	43.40
	Phase "Y"	41.05
	Phase "B"	39.61
	Total	**123.66**
Apparent Power (KVA)	Phase "R"	44.74
	Phase "Y"	41.89
	Phase "B"	40.01
	Total	**126.64**
Power Factor (P.F.)	Phase "R"	0.97
	Phase "Y"	0.98
	Phase "B"	0.98
Voltage THD %	Phase "R"	4.1
	Phase "Y"	4.9
	Phase "B"	2.5
Current THD %	Phase "R"	8.7
	Phase "Y"	7.1
	Phase "B"	4.1

Transformer Loading

Description	Transformer	Power	Maximum Apparent	Average Apparent	Max	Average

	Capacity	factor	power	Power	Loading	Loading
	kVA	PF	kVA	kVA	%	%
TR1	300	0.98	273	126.64	91	42.2

Observation Based on Ranking

- The measurement taken at the transformers includes data logging for every 5 seconds for 24 hours and during the logging period it was found that the average Voltage (L-L) for the transformer is 420V, which is slightly on the higher side. Therefore, it is suggested to maintain the Voltage level at 400 ± 10 by changing the tap position of the transformer.
- The average P.F. is 0.98, which is satisfactory.
- Voltage and Current harmonics are within limits.

Effects of High and Low Voltage

Wide Voltage fluctuation is a common phenomenon all over the country. Generally, the voltage is very low during the daytime and high during night hours. Therefore, Industrial Units running round the clock, face the problem of both Low and High Input Voltage. Also, voltage fluctuation is a seasonal phenomenon and increases in the summer season. Moreover, on holidays, peakhours, rainy days and when the agricultural load is switched off, the voltage risessharply in the feeder lines. There are few consumers of electricity, during such days, leading to comparatively lower voltage drop in the feeder lines; as a result,consumers suffer from high voltage which is more dangerous.

Most electrical equipment is designed for 230 volts (single-phase) or 410 volts (3-phase) and operates with optimum efficiency at its rated voltage. 50% of industrial load consists of motors. Due to continuously varying voltage and especially during peaks, electric motors draw considerably high current at high voltage which increases energy consumption, increases MDI and reduces power factor etc. These excessive power losses of motors generated at higher voltage results in premature failure of electrical equipment.

Similar is the case with single-phase equipment such as bulbs and tubes, when voltage increases above 230 volts. For example, at 270 volts is the power Consumption of 60 W bulb increase by almost 40% and the life of the bulb reduces from normal 1000 Hours to mere 100 Hours only (as per analysis report of ISI marked bulb manufacturers)

Transformer Loading & Efficiency

The efficiency of the transformers not only depends on the design but also, on the effective operating load. The variable losses depend on the effective operating load on the transformer. The maximum efficiency of the transformer occurs at a condition when the constant loss is equal to variable loss. For distribution transformers, the core loss is 15 to 20% of full load copper loss. Hence, the maximum efficiency of the distribution transformers occurs at a loading between 40 – 60%. For power transformers, the core loss is 25 to 30% of full load copper loss. Hence, the maximum efficiency of the power transformers occurs at a loading between 40 – 60%.

All the electrical parameters required evaluating percentage loading & losses of Transformers were recorded for old building transformers. No load and full load losses of the transformer are obtained from standards tocalculate the transformer losses as follows.

Note: Total loss = No load loss at Full load loss*(% Loading 2)

The efficiency of the transformers not only depends on the design but also, on the effective operating load. The variable losses depend on the effective operating load on the transformer.

Maximum Transformer load is 91% noted during power quality analysis. There is possibility of overloading in future. Transformer efficiency decreases as transformer winding losses increases at such > 90% loading. The university must plan to enhance transformer rating by addition of one moretransformer. Maximum demand is less than contract demand, no penalty charges were observed during last one year.

Total Energy Consumption

The University has facilities of Air Conditioning, Lighting system, Fans, Lifts and Fire Fighting System in the Block A, Block B, Block C, Block D, Block E, Block F, Block G, Block H, and Hostels of the University.

Electrical Equipment List in the University

S. No.	Equipment Name	Power	Qty
1	Ceiling Fan	65W	2080
2	Tube Light	20W	2621
3	2” ×2” LED Light	36W	232
4	9” ×8” LED Light	9W	560
5	LED Round White	12W	
		15W	
		18W	

		20W 30W	1131
6	LED Street Light	20W 36W 100W	41
7	Air conditioner	1.5T 1.8T 2.2T 4.0T	170
8	UPS	5KVA 10KVA 25KVA 50KVA	8
9	Water Motor Pump Mono block	2HP	5

Distribution of Load in the University

Load (KW) Distribution				
Facility Operated	**University**	**Hostels**	**Total**	**%age**
AC	272	123.7	395.7	**59.95**
Lighting	63.9	42	105.9	**16.04**
Fan	92.7	59.8	152.5	**23.10**
Computer & Laptop	6	0	6	**0.91**
Total	434.6	225.5	660.1	100.00
%age	**65.84**	**34.16**		

Air Conditioner System

The Institute has installed 170 Nos. Window, Split and Cassette AC for human comfort.

S. No.	**Quantity**		
	Split	**Window**	**Cassette**
1.5 Ton AC	86	-	-
1.8 Ton AC	25	-	-
2.2 Ton AC	52	-	-

4.0 Ton AC	09	-	-
Total ACs	**170**		

The analysis was done to identify the measures that could be undertaken to reduce the energy consumption. The following parameter has studied in each unit.

- Air flow rate
- Air flow cross section area
- Return dry bulb temperature
- Return wet bulb temperature
- Power consumption
- Supply dry bulb temperature
- Supply wet bulb temperature

Parameters	**Units**	**Split ACs**					
Location		Classroom	Classroom	Classroom	Classroom	Classroom	Classroom
Design Capacity	TR	2.2	2.2	2.2	2.2	2.2	2.2
Total Area	m^2	0.108	0.108	0.108	0.108	0.108	0.108
Measured avg. Velocity	m/s	4.3	4.2	2.9	2.2	2.9	4.6
Calculated Flow	m^3/hr	1671.8	1633.0	1127.5	855.4	1127.5	1788.5
Supply Air Dry Bulb Temp.	C^0	26	26	25	24	25	23
Supply Air Wet Bulb Temp.	C^0	20	21	17	16	18	19
Enthalpy supply air	KCal/Kg	13.7	14.5	11.4	10.7	12.1	12.9
Return Air Dry Bulb Temp.	C^0	27	29	28	26	28	29
Return Air Wet Bulb Temp.	C^0	23	25	22	23	23	23
Enthalpy return air	KCal/Kg	16.27	17.21	15.36	16.27	16.26	15.36
Density of Air	Kg/M^3	1.225	1.225	1.225	1.225	1.225	1.225
Calculated Capacity	TR	1.76	1.79	1.82	1.94	1.90	1.79
Power Consumption	KW	3.02	3.1	3	3.1	3.1	3.2
KW/TR		1.715	1.729	1.646	1.595	1.635	1.788
EER		6.997	6.939	7.290	7.525	7.337	6.711
COP		2.049	2.032	2.135	2.203	2.149	1.965

Observation: AC can be replaced with five-star AC, AC is used for human comfort in Classrooms and office area. AC used in office areas are in two- and three-star rating. Recommendations Replace old AC with five-star rating AC. Consider first phase to replace 9 AC.

- Cost Benefit Analysis of 3-star AC to 5-star AC

Water Pumps

Kalinga University has supply from Municipal water to meet the requirement for usage in University, Hostel and Washrooms. All the pumps are running as per the requirement. The detailed operating parameters of these pumps were measured to analyses the performance and it is given below.

- Suction pressure
- Discharge pressure
- Power consumption
- Flow rate

Lighting System

The University has already implemented energy efficient measures in lighting areas at different places. All conventional lamps are replaced by LED Lamps.

Blocks	**LED Consumption (Kwh)**	%age
Block A	8.22	7.62
Block B	7.22	6.69
Block C	11.89	11.02
Block D	12.97	12.02
Block E	12.93	11.98
Block F	11.30	10.47
Block G	11.40	10.57
Block H	10.90	10.10
Hostel - Boy	8.93	8.28
Hostel - Girl	7.09	6.57
Outer Area	5.04	4.67
Total Consumption (KWH)	107.89	

Observations

- It is recommended to install occupancy sensors ex. restroom, offices, lobby, staircases, panel room etc.
- University has opted for the latest LED technology for lighting.
- Lux was found satisfactory in many palaces but in some places, it is different from standard. It can be maintained as per university requirement.

Recommended value of illumination given as per National Building Code of India, 2005 clause 4.1.3, 4.1.3.2, 4.3.2 and 4.3.2.1

- Details of measured LUX in University

S.NO.	LOCATION NAME	MIN LUX	MAX LUX	Recommendation
1	Ground Floor	121	126	100-200
3	DG Room	150	170	100-200
4	Classrooms	310	450	300
5	Lecture rooms (including Demonstration areas)	310	450	300
6	Reading rooms	250	450	300-500
7	Laboratories	530	670	500-750
8	Corridors	150	170	150
9	Libraries	210	295	300
10	Moot court	245	450	300-500
11	Stage area	125	325	300
12	Canteen	80	120	100
13	Staff Room	155	185	150

Computer and Other Power Devices

University is using approximately 1200 nos. of computer and other power electronic devices.

An average desktop computer uses between 60 and 300 watts. It is very difficult to know exactly how much computers use on average because thereare so many different hardware configurations. We estimate that an averagemodern desktop PC will use approximately 100 watts of power per day approximately 4-6 hrs working per day.

Total consumption of electricity for 1200 computers per day = 120 KWH= 2400 KWH per month

Considering 250 days of working power consumption = 250 X 110 = 30000 KWH

To save energy, turn off the computer when it is not being used or enable power saving features such as hibernate, standby or sleep mode. Power savingmodes will allow you to turn on a computer quickly when you need to use it.
Sleep mode typically uses only 1-5 watts of power and can be set to turn on automatically after a set time of inactivity.

DG Performance

Two DG installed of ratings – 2 X 250 KVA, DGs were running for power cuts. No major power cuts were observed. Total diesel consumed = 22094 Liters.

Observation -

- Logbooks for DG were not maintained by the University. It is recommended to maintain a proper logbook for DG sets. This will help them to evaluate the specific power generation i:e kWH/litre of DG sets on a periodic basis. Sample Log Sheet for DG performance monitoring is shown in below table

Date	Time Start	Time Stop	Running Hours	Power Generated (Kwh)	Fuel Tank			Specific Power Consumption
					Initial Dip (mm)	Final Dip (mm)	Diesel Consumed (Ltr)	(Kwh/ltr)

Fans

KALINGA UNIVERSITY has installed many fans for the comfort of the employeesand students. The fans are regular fans consuming 70 watts each. The auditors recommend the use of Energy efficient BLDC Fans which consume less power.

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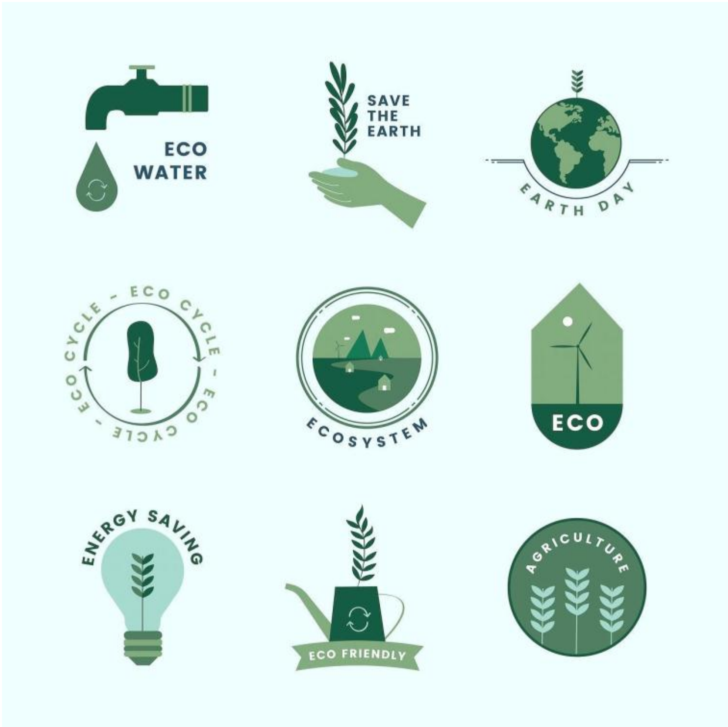
- Saving Calculation of Ceiling Fans

Parameter	Unit of Measurement	Existing	Proposed
Ceiling Fan Type		Induction Motor	Brushless DC Motor
No. of Fans	Nos	2080	2080
Power Consumption	Watts	65	25
Hours of Operation per year	Hours	1600	1600
Energy Consumed Annually	kWh/Fan	104	40
Saving in Energy	kWh/Fan		64
For 2080 fans	kWh		133120
Saving in Rs	Rs		13,31,200/-

Investment	Rs		6240000
Payback	Years		4.6

General Tips for Energy Conservation inDifferent Utilities



- Minimize maximum demand by tripping loads through a demand controller.
- Use standby electric generation equipment for on-peak high load periods.
- Correct power factor to at least 0.99 under rated load conditions.
- Provide proper ventilation
- For every 10°C increase in motor operating temperature over recommended peak, the motor life is estimated to be halved.
- Check for under-voltage and overvoltage conditions.
- Use smooth, well-rounded air inlet cones for fan air intakes.
- Avoid poor flow distribution at the fan inlet.
- Minimize fan inlet and outlet obstructions.
- Clean screens, filters, and fan blades regularly.
- Clean screens and filters regularly.
- Minimize blower speed.
- Use low-slip or no-slip belts.
- Operate pumping near the best efficiency point.
- Modify pumping to minimize throttling.

- Adapt to wide load variation with variable speed drives or sequenced control of smaller units.
- 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.
- Tune up the HVAC control system.
- Consider installing a Plant automation system (BAS) or energy management system (EMS) or restoring an out-of-service one.
- Balance the system to minimize flows and reduce blower/fan/pumppower requirements.
- Reduce excessive illumination levels to standard levels using switching, de-lamping, etc. (Know the electrical effects before doing de-lamping.)
- Aggressively control lighting with clock timers, delay timers, photocells, and/or occupancy sensors.
- Consider painting the walls a lighter colour and using less lighting fixtures or lower wattages.
- Use task lighting and reduce background illumination.
- Use waste heat to generate steam/hot water /power an absorption chilleror preheat process or utility feeds.
- Use jacket and head cooling water for process needs
- Clean air filters regularly
- Seal exterior cracks/openings/gaps with caulk, gasketing, weather stripping, etc.
- Consider new thermal doors, thermal windows, roofing insulation, etc.
- Install windbreaks near exterior doors.