Paper 3 – Set A Key

Regn No: _________________

Name: ___________________

(To be written by the candidate)

11^{th} NATIONAL CERTIFICATION EXAMINATION – February, 2011
FOR
ENERGY MANAGERS & ENERGY AUDITORS

PAPER – 3:	**Energy Efficiency in Electrical Utilities**		
Date: 06.02.2011	Timings: 0930-1230 HRS	Duration: 3 HRS	Max. Marks: 150

General instructions:

- *Please check that this question paper contains **17** printed pages*
- *Please check that this question paper contains **64** questions*
- *The question paper is divided into three sections*
- *All questions in all three sections are compulsory*
- *All parts of a question should be answered at one place*

Section – I: OBJECTIVE TYPE **Marks: 50 x 1 = 50**

(i) Answer all **50** questions.
(ii) Each question carries **one** mark.
(iii) Please hatch the appropriate oval in the OMR answer sheet with Black Pen or Black HB Pencil, as per instructions.

1.	Select the wrong statement: a) lower the heat rate of a power generating unit, higher is the generation efficiency. b) one kilo Watt hour of electrical energy being equivalent to 3600 kilo Joules of thermal energy <u>c) 'Heat Rate' is directly proportional to the efficiency of power generation.</u> d) design 'Heat Rate' of a 210 MW thermal generating unit is higher than that of a 110 MW thermal generating unit.
2.	If power factor is improved from PF1 to PF2 then the reduction in distribution losses in an electric network is proportional to : a) ratio of PF1 to PF2 b) square root of (PF1/PF2) <u>c) square of (PF1/PF2)</u> d) none of the above
3.	In the BEE labeling programme for distribution transformers, the total transformer losses at <u>a) 50% and 100% loading have been defined.</u> b) only 50% loading have been defined. c) only 100% loading have been defined. d) 25%, 50% and 100% loading have been defined.
4.	A 5 kVAr, 415 V rated power factor capacitor was found to be having 5.5 kVAr operating capacity. The operating supply voltage at the same supply frequency would approximately be a) 400 V b) 415 V <u>c) 435 V</u> d) none of the above

5.	Busbar Voltages at the main electrical panel were balanced but at the following Motor Control Circuit (MCC), fitted with PF Correction capacitors, the voltages were unbalanced by about 3%. The possible reason for this could be a) motors connected to MCC were operating at partial loads b) motors connected to MCC were overloaded c) excessive kVAr of Capacitors than required at MCC d) blown fuse in one phase of the 3 phase capacitor bank connected to the MCC.
6.	The iron losses in a transformer are proportional to : a) kVA load b) square of kVA load c) cube of kVA load d) none of the above
7.	The synchronous speed (rpm) of a 2 pole induction motor at 49.5 Hz supply frequency is : a) 3000 b) 2970 c) 1500 d) none of the above
8.	kW rating indicated on the name plate of an induction motor indicates a) rated input of the motor b) maximum input power which the motor can draw c) rated output of the motor d) maximum instantaneous input power of the motor
9.	A 7.5 kW, 415 V, 14.0 A, 1480 RPM, three phase rated squirrel cage induction motor, after decoupling from the driven equipment, was found to be drawing 3.5 A at no load. The current drawn by the motor at no load is high because of a) very high supply frequency at the time of no load test b) faulty ammeter reading c) very poor power factor as the load is almost inductive d) loose motor terminal connections
10.	A six pole induction motor operating at 49.6 Hz, with 980 RPM actual speed , will have operating % slip of a) 1.21% b) 2% c) 0% d) none of the above
11.	The total loss for a transformer loading at 60% and with no load and full load losses of 3 kW and 25 kW respectively, is a) 3 kW b) **12 kW** c) 18 kW d) 25 kW
12.	Eff1 (as per IS 12615:2004) induction motor is a) endorsed by BEE as high efficiency label b) having same efficiency as of Eff2 c) having less efficiency than Eff 2 motor d) not covered in BEE labeling scheme for motors
13.	Select the incorrect statement a) required PF capacitor kVAr at induction motor terminal increases with decrease in speed of the motor b) PF capacitor improves power factor from the point of installation back to the load side. c) induction motor efficiency increases with increase in its rated capacity d) The largest potential for electricity savings with variable speed drives is generally in variable torque applications
14.	The adsorption material used in an adsorption air dryer is a) calcium chloride b) magnesium chloride c) activated alumina and silica gel d) potassium chloride
15.	In a textile mill, two 150 cfm belt driven reciprocating compressors are seen to be working constantly with a loading time of 20 seconds and unloading time of 30 seconds. The best economic option for energy savings would be: a) switch off one compressor b) switch off one compressor and reduce motor pulley size of the other compressor appropriately c) adopt variable speed drive for one of the compressors

	d) none of the above
16.	Which of the following pipe fittings used in compressed air pipeline offers maximum resistance a) Gate Valve b) Tee 90 deg long bend c) Elbow d) Return bend
17.	A package air conditioner of 5 TR capacity delivers a cooling effect of 4 TR. If EER (W/W) is 2.90, the power in kW drawn by compressor would be: a) 4.85 b) 1.38 c) 1.724 d) none of the above
18.	In an air washer of textile humidification system airflow of 3000 m^3/h at 25 ^oC and 10% relative humidity is humidified to 60% relative humidity by adding water through spray nozzles. The specific humidity of air at inlet and outlet are 0.002 kg/kg and 0.0062 kg/kg respectively .The amount of water required in kg/hr is a) 14.9 b) 6 c) 10 d) none of the above
19.	In a vapour compression refrigeration system, the component where the refrigerant fluid experiences no heat loss or gain is a) compressor b) condenser c) expansion valve d) evaporator
20.	The refrigeration load in TR when 20 m^3/hr of water is cooled from 13 ^oC to 8 ^oC is about a) 33 b) 80.3 c) 39.6 d) none of the above
21.	In an engine room 15 m long, 10 m wide and 4 m high, ventilation requirement in m^3/hr for 20 air changes/hr is: a) 6000 b) 9000 c) 12000 d) none of the above
22.	The specific ratio as defined by ASME and used in differentiating fans, blowers and compressors, is given by a) discharge pressure/suction pressure b) suction pressure/discharge pressure c) discharge pressure/ (suction pressure + discharge pressure) d) suction pressure/ (suction pressure + discharge pressure)
23.	Friction loss in a piping system carrying fluid is proportional to a) fluid flow b) (fluid flow)^2 c) 1/fluid flow d) 1/(fluid flow)^2
24.	The efficiency of backward-inclined fans compared to forward curved fans is__ a) lower b) higher c) same d) none of the above
25.	For centrifugal fans, the relation between shaft input Power (kW) and Speed (N) is given by a) $\frac{kW_1}{kW_2} = \frac{N_1}{N_2}$ b) $\frac{kW_1}{kW_2} = \frac{{N_1}^2}{{N_2}^2}$ c) $\frac{kW_1}{kW_2} = \frac{{N_1}^3}{{N_2}^3}$ d) none of the above
26.	The value, by which the pressure in the pump suction exceeds the liquid vapour pressure, is expressed as a) static head b) dynamic head c)suction head d) net positive suction head available
27.	In a pumping system the static head is 10 m and the dynamic head is 15 m. If the pump speed is doubled, then the total head will be a) 50 m b) 70 m c) 40 m d) none of the above
28.	The advantage of installing a dedicated servo transformer for lighting feeders is; a) "Voltage" fluctuations in lighting circuit can be minimized by isolating from the power feeders. b) reduction of voltage related problems, which in turn increases the efficiency of the lighting system. c) with proper control device "over voltage" that might occur during lean load or off-peak can be avoided, in turn less energy consumption and improved lamp life can be achieved

	d) <u>all the above</u>
29.	Parallel operation of two identical fans in a ducted system a) will double the flow b) will double the fan static pressure c) will increase flow by more than two times d) <u>will not double the flow</u>
30.	The COP of a vapour compression refrigeration system is 3.0. If the compressor motor output is 9.555 kW, the tonnage (TR) of the refrigeration system is a) <u>8.15</u> b) 28.665 c) 3 d) none of the above
31.	A cooling tower is said to be performing well when: a) range is close to zero b<u>) approach is close to zero</u> c) approach is more than design values d) range is equal to approach
32.	A process fluid at 40 m^3/hr, with a density of 0.95, is flowing in a heat exchanger and is to be cooled from 35 ^oC to 29 ^oC. The fluid specific heat is 0.78 kCal/kg. If the chilled water range across the heat exchanger is 4 ^oC, the chilled water flow rate is <u>a) 44.46 m^3/hr</u> b) 40 m^3/hr c) 35 m^3/hr d) none of the above
33.	Input power to the motor driving a pump is 30 kW. The motor efficiency is 0.9. The power transmitted to the water is 16.2 kW. The pump efficiency is a) 54% b) <u>60%</u> c) 90% d) none of the above
34.	The most energy intensive dryer among the following a) refrigeration b) desiccant (heat of compression) <u>c) desiccant (heatless purge)</u> d) desiccant (blower reactivated)
35.	The illuminance is 10 lm/m² from a lamp at 1 meter distance. The illuminance at half the distance will be <u>a) 40 lm/m²</u> b) 10 lm/m² c) 5 lm/m² d) none of the above
36.	Harmonics are generated by a) energy efficient motors b) transformers c) eddy current drives d) <u>variable frequency drives</u>
37.	The main precaution to be taken care by the waste heat recovery device manufacturer to prevent the problem in a DG set during operation is: a) temperature rise b) <u>back pressure</u> c) over loading of waste heat recovery tubes d) turbulence of exhaust gases
38.	The lamp which gives 10% visible radiation is a) CFL b) flourescent tube light c) HPSV d) <u>incandescent lamp</u>
39.	The electronic ballast in lighting application does not have one of the following characteristics a) lower operational losses than conventional ballasts b) tuned circuit to deliver power at 28-32 kHz <u>c) requiring a starter</u> d) low temperature rise
40.	The lumens output varies from _______ Lumens/Watt in case of White LED lamps. a) <u>30-50</u> b) 75-125 c) 101-175 d) 67-121

41.	A fan is operating at 970 RPM developing a flow of 3000 Nm^3/hr. at a static pressure of 650 mmWC. If the speed is reduced to 700 RPM, the static pressure (mmWC) developed will be a) <u>388.5</u> b) 244.3 c) 469 d) none of the above
42.	The blowdown quantity required in cooling towers is given by <u>a) evaporation loss/ (cycle of concentration –1)</u> b) (cycle of concentration –1)/ evaporation loss c) evaporation loss/ (1 - cycle of concentration) d) evaporation loss/ (cycle of concentration +1)
43.	A hotel building has four floors each of 1000 m^2 area. If the Lighting Power Density (LPD) is 10.8 W/m^2, the interior lighting power allowance for the hotel building is a)10800 W b) 21600 W c) <u>43200 W</u> d) none of the above
44.	A DG set is generating 900 kVA at 0.8 PF. If the specific fuel consumption of this DG set is 0.3 lts/ kWh at that load, then how much fuel is consumed while delivering generated power for one hour. a) 270 litres b) 300 litres c) <u>216 litres</u> d) none of the above
45.	Energy Performance Index (EPI) kWh/m^2 /yr is calculated based on a) <u>total building annual electrical energy consumption/ built up area</u> b) total building annual electrical energy consumption/ carpet area c) total building annual electrical energy consumption for HVAC & lighting/ built up area d) none of the above
46.	Two most important electrical parameters, which are to be monitored on generator panel, among the following, for safe operation of a Diesel generator set are: a) voltage and ampere b) kVA and ampere c) power factor and voltage d) <u>kW and kVA</u>
47.	Which of the following is not a climate zone as per ECBC classification? a) hot-dry b) warm-humid c) cold d) <u>cold-humid</u>
48.	The T2,T5,T8 and T12 fluorescent tube light are categorized based on <u>a) diameter of the tube</u> b) length of the tube c) both diameter and length of the tube d) none of the above
49.	Select the feature which does not apply to energy efficient motors by design: a) energy efficient motors last longer b) starting torque for efficient motors may be lower than for standard motors c) <u>energy efficient motors have high slips which results in speeds about 1% lower than standard motors</u> d) energy efficient motors have low slips which results in speeds about 1% higher than standard motors
50.	Select the incorrect statement: a) Metal halide lamp can be considered as a variant of high pressure mercury vapour lamp (HPMV) b) <u>Efficacy of fluorescent tube light</u> (FTL) remains constant throughout its operational life c) HPSV lamps differ from mercury and metal-halide lamps in that they do not contain starting electrodes d) LPSV lamps are the most efficacious light sources, but they produce the poorest quality light of all the lamp types

…………. End of Section – I …………..…

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General instructions:

- *All questions are compulsory*
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Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

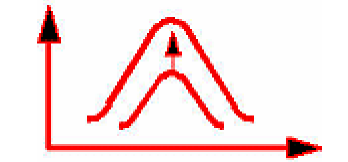
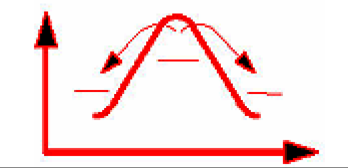
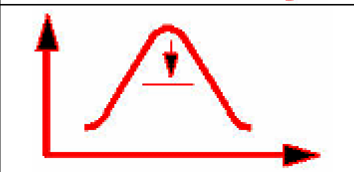
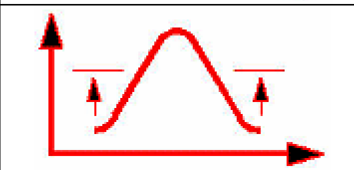
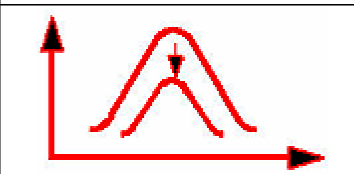
S-1 Compute AT & C (Aggregate Technical and Commercial) losses for the following data:

Description	**Annual Data**
Input energy = (import - export), MU	10
Energy billed (metered), MU	6
Energy billed (Un-metered), MU	1
Amount billed (Rs. lakhs)	400
Gross amount collected (Rs. lakhs)	410
Arrears collected (Rs. lakhs)	40

Ans:

Estimation of AT & C Losses			
S. No.	**Description**		**Annual Data**
1	Input Energy = (Import-Export), MU	Ei	10
2a	Energy Billed (Metered), MU	E1	6
2b	Energy Billed (Un-Metered), MU	E2	1
2c	Total Energy Billed (E1 + E2)	Eb	7
3	Amount Billed (Rs. lakhs)	Ab	400
4a	Gross Amount Collected (Rs. lakhs)	AG	410
4b	Arrears Collected (Rs. lakhs)	Ar	40
4c	Amount Collected without Arrears (Rs. lakhs)	Ac=AG-Ar	370
5	Billing Efficiency (BE)	= Eb/Ei *100%	70%
6	Collection Efficiency(CE)	=Ac/Ab *100%	93%
7	AT& C Loss	{1- (BE *CE) *100%	35%

S-2 Match the following load-shape objectives of any Demand Side Management (DSM) programme of a utility.

i	Peak Clipping	a	
ii	Valley filling	b	
iii	Load shifting	c	
iv	Conservation	d	
v	Load building	e	

Ans:

i – c; ii – d; iii – b; iv – e; v - a

S-3 The power input to a three phase induction motor is 52 kW. If the induction motor is operating at a slip of 1.9% and with total stator losses of 1.30 kW, find the total mechanical power developed.

Ans:

Stator input: 52 kW
Stator losses: 1.30 kW
Stator output: 52-1.30= 50.7kW = Rotor input

Slip= 1.9%
Mechanical Power Out put= (1-s)x Rotor Input
= (1- 0.019) x 50.7=0.981x 50.7=49.737 kW

S-4 In a Commercial building, five window ACs each of 1.5 TR capacity, were evaluated for replacement with three star labeled new ACs having Energy Efficiency Ratio (EER) of 2.50 kW/kW. The measured EER of existing ACs is as follows.

	<u>**Existing EER**</u>
AC No 1	2.05
AC No 2	2.19
AC No 3	2.30
AC No 4	2.40
AC No 5	2.17

Calculate the total kW saving potential if all the existing ACs are replaced with 3 star labeled ACs of same capacity?

Ans:

Input kW = TR delivered*3.516/EER

For 3 star AC input power = 1.5 x 3.516/2.5 = 2.11 kW

The power consumption of existing ACs works out as follows:

	Existing kW input
AC No1	2.573
AC No2	2.408
AC No3	2.293
AC No4	2.198
AC No5	2.430
Total	11.902

Savings potential = 11.902 – (2.11 x 5)
= 1.352 kW

S-5 The following data of a water pump of a process plant have been collected

Flow: 70 m^3/hr, Total head: 24 meters, Power drawn by motor– 7.2 kW, Motor efficiency – 89%. Determine the pump efficiency

Ans:

Hydraulic power	Q (m^3/s) x total head (m) x 1000 x 9.81 /1000
	(70/3600) x 24 x 1000 x 9.81/1000
Hydraulic power	4.578kW
Power input to pump	7.2x 0.9
	6.48 kW
Pump efficiency	4.578/6.48

	70.65 %

S-6 List any 5 energy conservation opportunities in agriculture pump sets

Ans:

The following energy conservation opportunites have been demonstrated for energy saving in agricultural pumping.

- Installation of low friction foot valves
- Installation of low friction HDPE suction and delivery pipes
- Installation of long bends
- Installation of high efficiency pumps and motors
- Lower discharge head

S-7 Write any 5 industrial applications of a heat pump.

Ans:

Industrial heat pumps are mainly used for:

- Space heating
- Heating of process streams
- Water heating for washing, sanitation and cleaning
- Steam production
- Drying/dehumidification
- Evaporation
- Distillation
- Concentration

S-8 An induced draft-cooling tower is designed for a range of 8 °C. The energy auditor finds the operating range as 2 °C during the conduct of energy audit. In your opinion what could be the reasons for this situation

Ans:

1. There may be excess cooling water flow rate
2. There may be reduced heat load from the process
3. Some of the cooling tower cells fan are switched off
4. Approach may be poor because of high humid condition
5. Cooling tower nozzles may be blocked

-------- End of Section – II ---------

Section – III: LONG DESCRIPTIVE QUESTIONS **Marks: 6 x 10 = 60**

i. Answer all **Six** questions
(ii) Each question carries **Ten** marks

L-1 The contract demand of a process plant is 6000 kVA with the electricity supply utility company. The average monthly recorded maximum demand of the process plant is 5500 kVA at a power factor of 0.78. The utility bill analysis provides the following tariff structure.

a) Minimum monthly billing demand is 75% of the contract demand or the actual recorded maximum demand whichever is higher. No PF improvement incentives are provided.

b) Monthly maximum demand (MD) charge is Rs. 400 per kVA.

Find out the optimum limit of power factor capacitor requirement entirely from the view of reducing maximum demand so that no excess demand charges are paid to the supply company. Also work out the simple payback period, assuming cost of power factor capacitor installation along with automatic power factor correction controller is Rs. 500 per kVAr.

Ans:

Minimum payable demand = 6000 x 0.75 = 4500 kVA
Margin available for reduction of MD = 5500 – 4500 = 1000 kVA
Present maximum load in kW = 5500 x 0.78 = 4290 kW
Desired peak power factor to achieve MD of 4500 kVA = 4290/ 4500
= 0.9533

Power factor capacitor requirement to achieve the desired power factor
= 4290 [tan (Cos^{-1} 0.78) – tan (Cos^{-1} 0.9533)]
= 4290 (tan 38.74 – tan 17.579)
= 4290(0.80226-0.316815)
= 4290(0.4854)
=2083 kVAr

Cost of power factor capacitor installation = Rs. 500 per kVAr x 2083 kVAr = 10.4 lakhs
Monthly savings due to MD reduction = 1000 kVA
Yearly savings = 1000 x 400 x 12 = Rs. 48.0 lakhs
Simple payback period = investment cost / yearly savings = 10.4/ 48 = 0.21 years = 2.6 months

L-2 Fill in the blanks for the following

a) With increase in condensing temperature in a vapor compression refrigeration system, the specific power consumption of the compressor for a constant evaporator temperature will________

b) With increase in evaporator temperature in a vapor compression refrigeration system, while maintaining a constant condenser temperature, the specific power consumption of the compressor will ______
c) Lower power factor of a DG set demands_________excitation current
d) Slip power recovery system is used in _________ induction motor
e) If voltage is reduced from 230 V to 200 V for a fluorescent tube light, it will result in ____ power consumption
f) _____ fans are known as “non-overloading“ because change in static pressure do not overload the motor
g) ________head is the friction loss, on the liquid being moved, in pipes, valves and equipment in the system
h) Ratio of the light reflected by a surface to the solar light incident upon it, is called________
i) __________is the ratio of solar heat gain that passes through fenestration to the total incident solar radiation that falls on the fenestration
j) luminous flux incident on an object per unit area is defined as _________________

Ans:

a. increase
b. decrease
c. higher
d. slipring
e. reduced
f. backward-inclined
g. dynamic
h. Solar Reflactance
i. Solar heat gain coefficient
j. illuminance

L-3 A free air delivery test was carried out before conducting a leakage test on a reciprocating air compressor in an engineering industry and following were the observations:

Receiver capacity	:	12 m^3
Initial pressure	:	0.2 kg / cm^2 (g)
Final pressure	:	7.0 kg / cm^2 (g)
Additional hold-up volume	:	0.3 m^3
Atmospheric pressure	:	1.026 kg / cm^2 (a)
Compressor pump-up time	:	4.8 minutes

The following was observed during the conduct of leakage test during the lunch time when no pneumatic equipment/ control valves were in operation:

a) Compressor on load time is 40 seconds and unloading pressure is 7 kg/cm^2 (g)
b) Average power drawn by the compressor during loading is 95 kW
c) Compressor unload time and loading pressure are 90 seconds and 6.6 kg/cm^2 (g) respectively.

Find out the following:

(i) Compressor output in m^3/hr (neglect temperature correction)
(ii) Specific Power Consumption, kW/ m^3/hr
(iii) % air leakage in the system
(iv) leakage quantity in m^3/hr
(v) power lost due to leakage

Ans.

(i)

Compressor output m^3/minute : $\dfrac{(P_2 - P_1) \times \text{Total Volume}}{\text{Atm. Pressure} \times \text{Pump up time}}$

: $\dfrac{(7.0 - 0.2) \times 12.3}{1.026 \times 4.8}$ = 16.9834 m^3/minute

: 1019 m^3/hr

power consumption : 95 kW
output : 1019 m^3/hr

(ii)
Specific power consumption : 95/1019 = 0.093228 kW/m^3/hr

(iii) % Leakage in the system
Load time (T) : 40 secs.
Un load time (t) : 90 secs

% leakage in the system : $\dfrac{T}{(T+t)} x100$

: $\dfrac{40}{(40+90)} x100$

: 30.77%

iv) Leakage quantity : 0.3077x1019
: 313.54 m^3/hr

v) Power lost due to leakage : Leakage quantity x specific power consumption
: 313.54 x 0.093228
: 29.23 kW

L-4 An energy audit was conducted to find out the ton of refrigeration (TR) of an Air Handling Unit (AHU). The audit observations are as under.

Parameter	Values
Evaporator area (m^2)	10.0
Inlet velocity (m/s)	1.9
Inlet air DBT (°C)	21.5
RH (%)	75.0
Enthalpy (kJ/kg)	53.0
Out let air DBT (°C)	17.4
RH (%)	90.0
Enthalpy (kJ/kg)	46.4
Density of air (kg/m^3)	1.14

Find out the TR of AHU.

Ans:

AHU refrigeration load =

$$\frac{Air\ flowrate\,(m^3/h)\,x\,Density\,of\ air\,(kg/m^3)\,x\,Difference\,in\,enthalpy}{3024\ x\,4.18}$$

AHU $= \dfrac{(10.0\,x\,1.9\,x\,3600)\,x\,(1.14)(53-46.4)}{3024\,x\,4.18} =$ 40.71 TR

L-5 Write short notes on **any two** of the following:

a) Energy Efficiency Measures in Buildings
b) Building Management System (BMS)
c) Energy Conservation Building Codes (ECBC)

Ans:

a) Energy Efficiency Measures in Buildings

<u>Air-Conditioning System</u>

Weather Stripping of Windows and Doors

Minimise exfiltration of cool air and infiltration of warm air through leaky windows and doors by incorporating effective means of weather stripping. Self-closing doors should also be provided where heavy traffic of people is anticipated.

Temperature and Humidity Setting

Ensure human comfort by setting the temperature to between 23^{o}C and 25^{o}C and the relative humidity between 55% and 65%.

Chilled Water Leaving Temperature

Ensure higher chiller energy efficiency by maintaining the chilled water leaving temperature at or above 7^o C. As a rule of thumb, the efficiency of a centrifugal chiller increases by about 2¼ % for every 1^o C rise in the chilled water leaving temperature.

Chilled Water Pipes and Air Ducts

Ensure that the insulation of the chilled water pipes and ducting system is maintained in good condition. This helps to prevent heat gain from the surroundings.

Chiller Condenser Tubes
Ensure that mechanical cleaning of the tubes is carried out at least once every six months. Fouling in the condenser tubes in the form of slime and scales reduces the

heat transfer of the condenser tubes and thereby reducing the energy efficiency of the chiller.

Cooling Towers

Ensure that the cooling towers are clean to allow for maximum heat transfer so that the temperature of the water returning to the condenser is less than or equal to the ambient temperature.

Air Handling Unit Fan Speed

Install devices such as frequency converters to vary the fan speed. This will reduce the energy consumption of the fan motor by as much as 15%.

Air Filter Condition

Maintain the filter in a clean condition. This will improve the heat transfer between air and chilled water and correspondingly reduce the energy consumption.

<u>Lighting System</u>

Switch off Lights When Not In Use

Provision of Separate Switches for Peripheral Lighting

A flexible lighting system, which made use of natural lighting for the peripherals of the room, should be considered so that these peripheral lights can be switched off when not needed.

Install High Efficiency Lighting System

Use lamps with high luminous efficacy. For example, replacing incandescent bulbs with compact fluorescent lamps can reduce electricity consumption by 75% without any reduction in illumination levels.

Fluorescent Tube Ballasts

The ballast losses of conventional ballast and electronic ballast are 12W and 2W respectively. Hence, consider the use of electronic ballast for substantial energy savings in the lighting system.

Lamp Fixtures or Luminaires

Optical lamp luminaries made of aluminum, silver or multiple dielectric coatings have better light distribution characteristics. Use them to reduce electricity consumption by as much as 50% without compromising on illumination levels.

Integration of Lighting System with Air-Conditioning System

In open plan offices, the air-conditioning and lighting systems can be combined in such a way that the return air is extracted through the lighting luminaires. This measure ensures that lesser heat will be directed from the lights into the room.

Cleaning of Lights and Fixtures

Clean the lights and fixtures regularly. For best results, dust at least four times a year.

Use Light Colors for Walls, Floors and Ceilings

The higher surface reflectance values of light colors will help to make the most of any existing lighting system.

b) Building Management System (BMS)

Energy management systems can vary considerably in complexity and degree of sophistication. The simplest timing mechanism to switch systems ON and OFF at pre-determined intervals on a routine basis could be considered as an energy management system. These progresses to include additional features such as programmers, thermostatic controls, motorised valves, zoning, and optimum start controllers and compensated circuits.

The most complex of energy management systems have a computerised central controller linked to numerous sensors and information sources. These could include the basic internal and external range shown schematically in Figure 10.9, along with further processed data to include: the time, the day of the week, time of year, percentage occupancy of a building, meteorological data, system state feedback factors for plant efficiency at any one time and energy gain data from the sun. lighting, machinery and people.

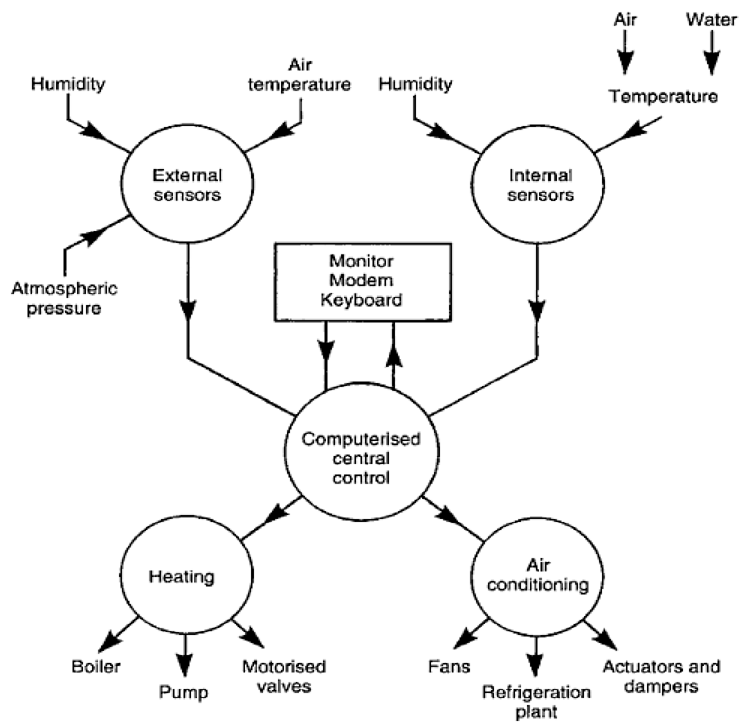


Figure :Building Energy Management

A microprocessor is the main feature of the control system. Data on temperature, flow rates, pressures, etc., as appropriate, are collected from sensors in the system and in the treated spaces and stored in the memory of the processor. Equations are developed for defining the performance of the control elements, the items of plant and the behavioural characteristics of the systems. These equations are fed into the micro-processor as algorithms. The deviations from the desired performance are dealt with by calculations using the equations fed in. This in turn controls the overall systems. So in effect, mathematical functions replace control modes.

For example, if the room temperature rose in a conditioned space, the correct position of the valve in the chilled water line feeding the AHU could be calculated and corrected as necessary, to bring the room temperature back to the set point as rapidly as possible. Data can be stored to establish trends and anticipation can be built into the program so that excessive swings in controlled conditions may be prevented. Based on the operating experience, self-correction can be incorporated to get the best possible system performance. This implies that, commissioning inadequacies and possibly even design faults can be corrected, but only to a certain extent. Only if the systems are properly designed, installed and commissioned, optimum results can be obtained and the cost of the installation can be justified.

The functions of a building management system (BMS) or building energy management system (BEMS) are monitoring and control of the services and functions of a building, in a way that it is economical and efficient in the use of energy. It may be arranged that one system can control a group of buildings.

c) Energy Conservation Building Codes (ECBC)

Energy Conservation Building Codes are developed to set minimum energy efficiency standards for design and construction of commercial and residential buildings, to encourage energy efficient design or retrofit of buildings so that it does not constrain the building function, comfort, health, or the productivity of the occupants.

In order to implement ECBC across the country in India, it has been decided to group the country in five climatic zones as per the weather conditions. The Five Climatic Zones are:

- Composite (Delhi)
- Hot-Dry (Ahmedabad)
- Warm-Humid (Kolkata)
- Moderate / Temperate (Bangalore)
- Cold (Shillong)

The ECBC considers the following aspects of the buildings:

a) Building envelopes, except for unconditioned storage spaces or warehouses,
b) Mechanical systems and equipment, including heating, ventilation and air conditioning,
c) Service hot water heating,
d) Interior and exterior lighting, and
e) Electrical power and motors.

The provisions of this ECBC code do not apply to:

a) Buildings that do not use either electricity or fossil fuel,
b) Equipment and portions of building systems that use energy primarily for manufacturing processes and
c) Multi-family buildings of three or fewer storey above grade, and single-family buildings.

L-6 A cooling tower cools 1450 m^3/hr of water from 43 ºC to 36.6 ºC at 30 ºC wet bulb temperature. The cooling tower fan flow air rate is 9,50,000 m^3/hr (air density =1.08 kg/m^3) and operates at 2.7 cycles of concentration.

Find out the following

a) Range
b) Approach
c) % CT Effectiveness
d) L/G Ratio in kg/kg
e) Cooling Duty Handled in TR
f) Evaporation Losses in m^3/hr
g) Blow down requirement in m^3/hr
h) Make up water requirement in m^3/hr

Ans:

*	CT Flow, m^3/hr	=	1450(1450000 kg/hr)
*	CT Fan Flow, m^3/hr	=	950000
*	CT Fan Flow kg/hr @ Density of 1.08 kg/m^3	=	1026000
d)	L/G Ratio of C.T. kg/kg	=	1.41325
			Mark: 1
a)	CT Range	=	(43 – 36.6) = 6.4ºC
			Mark: 1
b)	CT Approach	=	(36.6 – 30) = 6.6ºC
			Mark: 1
c)	% CT Effectiveness	=	100 * [Range/Range + Approach]
		=	100 * (6.4) / (6.4 + 6.6)
		=	49.23%
*			**Marks: 1**
e)	Cooling Duty Handled in kCal	=	1450 * 6.4 * 10^3
	(i.e., Flow * Temperature Difference in kCal/hr)	=	9280* 10^3 kCal/hr / 3024
		=	3068TR
			Marks: 2
f)	Evaporation Losses in m^3/hr	=	0.00085 x 1.8 x 1450x 6.4
		=	14.1984m^3/hr
*	Percentage Evaporation Loss	=	[14.1984/1450]*100
		=	0.98%
			Marks: 2
g)	Blow down requirement for site COC of 2.7	=	Evaporation losses/COC–

1

= 14.198 /(2.7–1) = 8.352 m^3/hr

Mark: 1

h) Make up water requirement in m^3/hr	=	Evaporation Loss + Blow down Loss
	=	14.198 + 8.352
	=	22.55

……. End of Section – III …………….