19th NATIONAL CERTIFICATION EXAMINATION

FOR

ENERGY MANAGERS & ENERGY AUDITORS – SEPTEMBER, 2018

PAPER – 3 : ENERGY EFFICIENCY IN ELECTRICAL UTILITIES

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 **HB pencil only,** as per instructions

1.	Select the incorrect statement: a) Harmonics occur as spikes at intervals which are multiples of the supply frequency b) **Devices that draw sinusoidal currents when a sinusoidal voltage is applied create harmonics** c) Harmonics are multiples of the supply frequency d) Transformers operating near saturation level create harmonics
2.	The illuminance is 10 lm/m² from a lamp at 1 meter distance. The illuminance at half the distance will be a) None of the below b) 10 lm/m² c) 5 lm/m² d) **40 lm/m²**
3.	In an engine room 15 m long, 10 m wide and 4 m high, ventilation requirement in m3/hr for 20 air changes/hr is a) None of the below b) 9000 c) **12000** d) 6000
4.	A package air conditioner of 5 TR capacity delivers a cooling effect of 4 TR. If Energy Efficiency Ratio (W/W) is 2.90, the power in kW drawn by compressor would be: a) None of the below b) 1.38 c) 1.724 d) **4.84**
5.	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 be approximately. a) None of the below b) 415 V c) **435 V** d) 400 V
6.	The Solar Heat Gain Coefficient (SHGC) of window of a building is 0.30. This means that a) The window reflects back to exterior a minimum of 30 % of the sun's heat b) **The window allows 30 % of the sun's heat to pass through into the building interior** c) 70 % of the sun's heat is incident on the window d) The window allows 70 % of the sun's heat to pass through into interior of the buildings

7.	The most energy intensive heat transfer loop of a vapour compression refrigeration system is: a) **Condenser water loop** b) Chilled water loop c) Refrigerant loop d) Indoor air loop
8.	One of the thermal power plants operating with 2 nos. of 500 MW units has reported the operating heat rate of 11250 kJ/kW. The Plant Load Factor (PLF) of the power plant is 73 %. The operating efficiency of the power plant will be a) **32 %** b) 35 % c) 30 % d) 38 %
9.	Aggregate Technical & Commercial loss in distribution system covers a) **Energy and monetary loss** b) Transmission & distribution loss c) Only transmission losses d) I^2R losses of all transformers
10.	The power measured in a boiler ID fan is 52 kW operating at 49 Hz. As an energy conservation measure the Variable Frequency Drive (VFD) was installed and the fan was operated at 34 Hz. The estimated power savings will be a) 35 .7 kW b) 17.2 kW c) **34.7 kW** d) 36 kW
11.	The isothermal power of a 500 cfm air compressor is 72 kW and the efficiency is 78 %. The actual power drawn by the compressor will be a) None of the below b) **92 kW** c) 72 kW d) 56 kW
12.	A heat pump used in a heat recovery application extracts 66220 kcal/hr and the power consumed by the heat pump is 23 kW. The estimated heat supplied by the heat pump is a) **86000 kcal/hr** b) 47300 kcal/hr c) 86860 kcal/hr d) 2916 kcal/hr
13.	A coal fired boiler primary air fan is maintaining a velocity pressure of 70 mmWC and the air temperature is 380C. The density of the air is 1.135 kg/m3 and the pitot tube constant is 0.85. The velocity of air in m/sec will be a) None of the below b) **29.56** c) 28.67 d) 25.6
14.	A two stage air compressor drawing 75 kW has heat rejection of 862 kCal/kWh. The required capacity of the cooling tower when the operating temperature difference of 5 0C will be ________TR. a) 57.4 b) 107.5

	c) 22.93		d) **21.55**
15.	The star rating scheme of Fluorescent Tube light as per BEE Standards & Labelling Scheme is based on		
	a) **Lumen per Watt at different operating hours**		b) Lux per Watt
	c) Lux per Watt per m^2		d) Lumen Output
16.	A pump with 230 mm diameter impeller is delivering a flow of 150 m3/hr. If the flow is to be reduced to 110 m3/hr by trimming the impeller, what should be the approximate impeller size ?		
	a) 207 mm		b) 175 mm
	c) **169 mm**		d) 195 mm
17.	Which of the following incandescent bulbs will have the least resistance ?		
	a) **115 V, 100 W**		b) 220 V, 100 W
	c) 115 V, 60 W		d) 220 V, 60 W
18.	In a rolling mill, the loading on the transformer was 1200 kVA with the power factor of 0.86. The plant improved the power factor to 0.98 by adding capacitors. What is the reduction in kVA ?		
	a) 163.3		b) **147**
	c) 171		d) 144
19.	A 22 kW, 415 V, 45 A, 0.8 pf, 1475 rpm, 4 pole 3 phase induction motor operating at 420 V, 40 A and 0.8 pf. What will be the motor efficiency ?		
	a) None of the below		b) 94.5 %
	c) 89.9 %		d) **85.0 %**
20.	The purpose of inter-cooling in a multistage compressor is to		
	a) None of the below		b) **Reduce the work of compression**
	c) Separate moisture and oil vapour		d) Increase the pressure of air
21.	One ton of refrigeration is not equal to__________.		
	a) **860 kCal/hr**		b) 3.51 kW
	c) 12000 Btu/hr		d) 3024 kCal/hr
22.	If two identical pumps operate in series, their shut-off head is		
	a) Less than double		b) More than double
	c) **Doubled**		d) Not affected
23.	Which of the following is not a part of vapour compression refrigeration cycle ?		
	a) **Generator**		b) Evaporator
	c) Condenser		d) Compressor

24.	If the power consumed by an air conditioner compressor is 1.7 kW per ton of referigeration, then its energy efficiency ratio (Watt/Watt) is _____ a) None of the below b) **2.1** c) 0.59 d) 1.7
25.	The adsorption material used in an adsorption air dryer is a) Potassium chloride b) Magnesium chloride c) **Activated alumina** d) Calcium chloride
26.	The cooling tower size is _____________ to the entering Wet Bulb Temprature (WBT), when the heat load, range and approach are constant. a) None of below b) **Inversely proportional** c) Constant d) Directly proportional
27.	The T5, T8 and T12 fluorescent tube light are categorized based on a) Power consumption b) Length of the tube c) Both diameter and length of the tube d) **Diameter of the tube**
28.	If the wet bulb temperature of air is 38 ^{0}C, then it's relative humidity is __________%. a) **Insufficient data** b) 90 % c) 100 % d) 38 %
29.	The hydraulic power in a pumping system depends on a) **None of the below** b) Motor efficiency c) Both motor and pump efficiency d) Pump efficiency
30.	Small diameter by-pass lines are installed in pumps sometimes to ________________. a) Reduce pump power consumption b) Control pump delivery head c) **Prevent pump running at zero flow** d) Save energy
31.	It is acceptable to run pumps in parallel provided their_________ are similar a) Total head at full flow b) Discharge heads c) **Closed valve heads** d) Suction heads
32.	L / G ratio in a cooling tower is the ratio of _________________. a) Air mass flow rate and water flow rate b) Length and Temperature gradient c) **Water flow rate and air mass flow rate** d) Length and girth
33.	Fiberglass Reinforced Plastic (FRP) fans consume less energy than aluminum fans because a) They deliver less air flow b) **They have better efficiencies** c) They encounter less system resistance d) They are lighter
34.	Ratio of luminous flux (lumen) emitted by a lamp to the power consumed (watt) by the lamp is called a) Luminance b) **Luminous efficacy** c) Reflectance d) Luminous intensity

35.	Illuminance of a surface is expressed in a) LPD b) **<u>Lux</u>** c) Lumens d) Radians
36.	Use of soft starters for induction motors results in a) All the below b) Lower power factor c) Higher maximum demand d) **<u>Lower mechanical stress</u>**
37.	The Energy Performance Index (EPI) of a building as per Energy Conservation Building Code (ECBC) and as defined in the Energy Conservation Act, 2001 is: a) kWh per year b) kWh per square meter c) kW per square meter d) **<u>kWh per square meter per year</u>**
38.	Energy Conservation Act covers buildings having a connected load of a) All buildings with HT connection b) 100 kVA and above c) 500 kW and above d) **<u>100 kW and above</u>**
39.	In a solar PV system the conversion from DC to AC is carried out by a) **<u>Inverter</u>** b) Charger c) Battery d) Converter
40.	The inlet air temperature to a two stage reciprocating air compressor is 35 0C. At which of the following 2nd stage inlet temperature's the compressor will consume least power ? a) **<u>50 ^{0}C</u>** b) 65 ^{0}C c) 60 ^{0}C d) 75 ^{0}C
41.	A fan is drawing 16 kW at 800 RPM. If the speed is reduced to 600 RPM then the power drawn by the fan would be a) None of the below b) 9 kW c) **<u>6.75 kW</u>** d) 12 kW
42.	In which of the following fans air enters and leaves the fan with no change in direction ? a) **<u>Propeller</u>** b) Backward curved c) Radial d) Forward curved
43.	Increasing the Cycles of Concentration (C.O.C) of circulating water in a cooling tower, the blow down quantity will a) None of the below b) **<u>Decrease</u>** c) Not change d) Increase
44.	__________ can be achieved using infrared, acoustic, ultrasonic or microwave sensors for energy efficient lighting control. a) Localized switching b) Daylight-linked control c) **<u>Occupancy-linked control</u>** d) Time-based control

45.	The 5th and 7th harmonic in a 50 Hz power supply system will have: a) No voltage and current distortion at all b) Voltage and current distortions with 500 Hz & 700 Hz c) **Voltage and current distortions with 250 Hz & 350 Hz** d) Voltage and current distortions with 55 Hz & 57 Hz
46.	A 7.5 kW, 415 V, 15 A, 970 RPM, 3 phase rated induction motor with full load efficiency of 86 % draws 7.5 A and 3.23 kW of input power. The percentage loading of the motor is about a) None of the below b) 43 % c) 50 % d) **37 %**
47.	A two pole induction motor operating at 50 Hz, with 1 % slip will run at an actual speed of a) None of the below b) 3030 RPM c) **2970 RPM** d) 3000 RPM
48.	The value, by which the pressure in the pump suction exceeds the liquid vapour pressure, is expressed as a) Suction head b)Static head c) Dynamic head d)**Net positive suction head available**
49.	Which of the following ambient conditions will evaporate minimum amount of water in a cooling tower ? a) 35 ^{0}C DBT and 29 ^{0}C WBT b) 38 ^{0}C DBT and 31 ^{0}C WBT c) **38 ^{0}C DBT and 37 ^{0}C WBT** d) 35 ^{0}C DBT and 30 ^{0}C WBT
50.	A fan is operating at 970 RPM developing a flow of 3000 Nm3/hour at a static pressure of 650 mmWC. If the speed is reduced to 700 RPM, the static pressure (mmWC) developed will be a) **None of the below** b) 650 c) 469 d) 244.3

-------- End of Section - I --------

Section – II: SHORT DESCRIPTIVE QUESTIONS Marks: 8 x 5 = 40

(i) Section II contains **Eight** questions (S1- S8)
(ii) Each question carries **Five** marks

S-1 During the performance evaluation of a DG set, the following parameters were noted

Capacity of DG set	1500	kVA
Test duration	36	minutes
Units generated	442	kWh

	<table><tr><td>Average Power factor</td><td>0.92</td><td>pf</td></tr><tr><td>Length of diesel tank</td><td>90</td><td>cm</td></tr><tr><td>Width of diesel tank</td><td>90</td><td>cm</td></tr><tr><td>Height of the diesel tank</td><td>90</td><td>cm</td></tr><tr><td>Initial tank dip level (from top)</td><td>63</td><td>cm</td></tr><tr><td>Final tank dip level (from top)</td><td>79</td><td>cm</td></tr></table> Calculate the following: 1. Diesel consumption (Litres) (1 Mark) 2. Average load (kW) (1 Mark) 3. Percentage Loading (%) (2 Marks) 4. Specific power generation (kWh/Litre) (1 Mark)
Ans	1. Diesel Consumption = 0.9x0.9x0.16 =129.6 Liters 2. Average load (kW) = (442/36)x60 =736.7 kW 3. Percentage Loading (%) = (736.7/.92)/1500 =53% 4. Specific power generation (kWh/Litre) (442/129.6) =3.41 kWh/Litre
S-2	In a Thermal Power Station, the steam input to a turbine operating on a fully condensing mode is 100 TPH. The heat rejection requirement of the steam turbine condenser is 555 kcal/kg of steam condensed. The temperature of cooling water at the inlet and outlet of the turbine condenser is 27 ^{0}C and 37 ^{0}C respectively. Find out the circulating cooling water flow.
Ans	The quantum of heat rejected in the turbine condenser = Quantum of steam condensed (kg) x heat rejection (kcal/kg) = 100,000 x 555 = 55.5 Million kcal/h. Heat gained by circulating cooling water = Heat rejected in the condenser Circulating cooling water flow = 100,000 x 555 / (37-27) x specific heat (1) = 5550 m^3/hr
S-3	A medium sized engineering industry has installed two 480 CFM screw compressors, A & B. Compressor-A is operating at full load and Compressor-B is running in load – unload condition. The load power of both the compressor is 74 kW and the unload power of the Compressor-B is 26 kW. Both the compressors are operated during working day.The percentage loading of the Compressor-B during working day is 64 %. After arresting the leakage in the system, the loading of the compressor was found to be 35 %. Estimate the energy savings per day.

Ans	**Existing Case:** Energy consumed per hour by Compressor -A= 74 kW Energy consumed per hour by Compressor -B= 0.64 x 74 + 0.36 X 26 = 56.72 kW Total energy consumed (Compressor A& B) = 74 + 56.72 = 130.72 kW/hr Energy consumed per day= 130.72 X 24 hrs = 3137.3 kWh/day **Leakage Calculation:** Energy consumed per hour by Compressor -B= 0.64 x 74 + 0.36 X 26 = 56.72 kW Energy consumed per hour by Compressor -B= 0.35 x 74 + 0.65 X 26 = 42.8 kW Difference in power consumption = 56.72 - 42.8 = 13.92 kW/hr Savings by arresting leakage per day= 13.92 X 24 = 334 kWh/day
S-4	A plant is operating a chilled water system always at full load. The chilled water inlet and outlet temperatures are 12 ^{0}C and 7 ^{0}C respectively. The chilled water pump discharge pressure is 3.6 kg/cm^{2}g and the suction is 5 meters above the pump centreline. The power drawn by the chilled water pump's motor is 70 kW and an efficiency of 90 %. The chilled water pump efficiency at the operating point from pump characteristic curve is 60 %. Find out the operating refrigeration load in TR.
Ans	Total head: 36 – 5 = 31 m Pump shaft power: 70 x 0.9 63 kW Flow rate: (63 x 1000) X 0.6 / 31 x 1000 x 9.81 0.124297 m^3/s 447.5 m^3/hr Refrigeration load: (447500 x 5) / 3024 740 TR
S-5	How does a motor lose its efficiency upon rewinding? (2.5 Marks) What two parameters will indicate the efficacy of the rewinding? (2.5 Marks)
Ans	• Refer Guide Book No 3, Chapter 2, Page No 61
S-6	The operating data of an induced draft-cooling tower is as follows: Observed range : 8 ^{0}C. Cooling water flow rate : 12,500 m^3/hr Drift loss : 0.1 % of circulation rate Wet Bulb Temperature : 27 ^{0}C Ambient Dry Bulb Temperature : 35 ^{0}C Effectiveness : 67 % Cycle of Concentration : 3 Estimate the evaporation loss; make up water requirement and TR load of cooling tower.

Ans	Evaporation loss = 0.00085 X 1.8 X 12500 X 8 = 153 m^3/hr Blow Down =153 /(3-1)= 76.5 m^3/hr Make up =153 + 76.5 + (12500*0.001)= 242 m^3/hr Heat load =12500*1000*8/3024 = 33069 TR
S-7	List any five benefits of power factor improvement in an industrial power distribution system.
Ans	Refer Guide Book No 3, Chapter 1, Page No 11
S-8	In an air washer of a textile humidification system with an airflow of 3000 m3/h at 25 0C 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 of dry air and 0.0062 kg/kg of dry air respectively. The density of air at 25 0C is 1.184 kg/m3. Calculate the amount of water required in kg/hr.
Ans	The amount of water required: $m_w = v\,\rho\,(\omega_{out} - \omega_{in})$ $= 3000 \times 1.184 \times (0.0062 - 0.002)$ $= 14.9$ kg/h

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

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

(i) Section III contains **Six** questions (L1- L6)
(ii) Each question carries **Ten** marks

L-1 A 7.5 TR package air conditioner is provided for a UPS room for removing the heat generated from the UPS of rated capacity 40 kVA. The following parameters were noticed while performing the assessment of the total system.

UPS Parameters:

Rating		**Input Power (kW)**	**Output Power (kW)**
40 kVA	On Load (16 hrs)	11.94	8.61
	No Load (8 hrs)	1.16	0.00

Air conditioner parameters:

Installed capacity of Air conditioner	7.5	TR
Outdoor unit (condenser) air velocity	6.1	m/s
Radius of the fan opening at the point of velocity measurement in outdoor unit	0.30	m
Air Density	1.174	kg/m^3

Ambient temperature	305	^{0}K
Temperature of hot air (condenser outlet)	313.5	^{0}K
Specific heat of air	1.009	kJ/kg K
Power drawn by the compressor	5.40	kW
Efficiency of the compressor motor	90	%

Calculate

a) Present delivery capacity of air conditioner (TR) (3 Marks)

b) Power drawn per TR of refrigeration (3 Marks)

c) Calculate the annual energy savings for 7200 hrs, if the UPS is relocated to a non air-conditioned ventilated area. Assume energy cost Rs.8/kWh. (4 Marks)

Ans

Capacity Installed	7.5	TR
Outdoor unit air velocity	6.1	m/s
Radius of the opening	0.30	m
Area of cross section (3.14x0.3^2)	0.283	m^2
Total Air flow (0.283x6.1)	1.72	m^3/s
Density of the air	1.174	kg/m^3
Mass of air, m (1.72x1.174)	2.02	kg/s
Ambient temperature, T1	305	^{o}K
Air temperature, T2	313.5	^{o}K
Difference in Temperature (T2-T1), (dT)	8.5	^{o}K
Specific Heat at Constant pressure, cp	1.009	kJ/kgK
Heat Transfer (mxCpx(T2-T1))	17.32	kJ/s
Heat transfer per hour	62352	kJ/hr
	14917	kcal/Hr
Heat input from the compressor (5.4x0.9x860)	4180	kcal/Hr
Evaporator heat load (14949-4180)	10737	kcal/Hr
1 Tonne of refrigeration	3024	kCal/Hr

Effective TR	**3.55**	**TR**
Power drawn by the compressor	5.40	kW
power taken per TR of refrigeration	**1.52**	**kW/ TR**

Heat Load generated by UPS in Conditioned Space								
Rating/ Location		Input Power (kW)	Output Power (kW)	Heat Load				
				(kW)	kCal/Sec	kCal/Hr	TR/hr	Total TR/day
40 kVA	On Load (16hrs)	11.94	8.61	3.33	0.80	2880	0.95	15.2
	No Load (8hrs)	1.16	0	1.16	0.28	1008	0.33	2.64
Total								17.84

The savings that can be achieved by providing clean, cool and dust free environment for UPS operation is given below.

AC Load generated by UPS/ day = 17.84 TR

Power taken by AC to generate 17.82 TR at 1.52 kW/ TR = 27.12 kW

Annual energy savings at 300 days of operation = 8136 **kWh**

Cost of power = Rs.8/ kWh

Annual Cost Savings = **Rs.65,088/-**

L-2 One of the textile processing plants has installed two numbers of 6 MW gas turbines and also Heat Recovery Steam Generator (HRSG) to generate steam from the hot gases. The steam generated from HRSG is utilized for process steam requirement and also for 500 TR Vapour Absorption Machine (VAM). The VAM consumes 4.4 kg steam per TR and is operated at full load.

Due to increase in gas price the plant has stopped gas turbine operations and avails power supply from the grid. To meet the steam requirement the plant has installed two numbers of 10 TPH Agro Waste Boilers and steam is supplied to the process plant as well as to VAM machine. The average cost of steam is Rs.1200/- per ton from agro waste boiler. The plant operates for 7000 hours in a year.

The management is planning to replace the VAM chillers by electrical centrifugal chiller which will operate at 0.7 kW/TR.

	Compare the annual operating costs of electrical chiller and VAM. The cost of grid power is Rs 6.12/kWh. Consider all the other auxiliary power remains same in both the cases. Do you agree with the management decision of operating VAM machine for chilling requirements?
Ans	Capacity of VAM Machine = 500 TR Steam required/TR =4.4 Kg/TR Total Steam requirement = 500 X 4.4 = 2200 Kg/hr= 2.2 TPH Cost of steam from Agro Boiler = 2.2 X 1200 = Rs 2640 / hr Power consumed by electric chiller = 0.7 X 500 = 350 kW Cost of electricity = Rs 6.12/kWh Operating cost of electric chiller = 350 x 6.12 = Rs 2142 Savings by Electric chiller = 2640- 2142 = Rs.498/ hr Annual operating savings = 7000 X 498 = Rs 34,86,000/- **Disagree with the management decision.**
L-3	A distribution company has taken initiatives to reduce Aggregate Technical &Commercial (AT & C) loss in their network. The energy supplied, received and revenue details are given below : Input energy = 60 MU Metered Billed Energy = 43 MU Average Billing= 3 MU Amount Billed=Rs. 540 Million Arrears collected = Rs. 80 Million Amount received = Rs. 470 Million a) Estimate the following : (each carries 2.5 Marks) i) AT & C loss in % and revenue realized in Rs./kWh. ii) Revenue loss per kwh and monthly loss, if the purchased energy cost is Rs. 8.10/kWh b) List five measures to reduce commercial loss in the network (5 Marks)
Ans	a) Billing efficiency = (43+3) /60 X 100 = 76.7 % Collection efficiency = ((470-80)/540) X 100 = 72.2 % AT&C Loss = 1- (Billing efficiency x Collection Efficiency) x 100

	= 1- (0.767 x 0.722) X100 = **44.62 %** Revenue realised / kwh = (470-80)/60 = Rs 6.5/kWh Revenue loss / kwh = Rs 8.10- 6.5 = Rs. 1.6/kWh Monthly Revenue loss = 60 X 1.6 =**Rs 96 Million or (Rs.9,60,00,000/-)** b) Few measures to reduce commercial losses in distribution system include: **Refer Guide Book No 3, Chapter 1, Page No 27**
L-4	Write short notes on the following with respect to the compressed air system : (each carries 2.5 Marks) a) Refrigeration drier b) Heat of compression drier c) Role of air receiver d) Dew point
Ans	**a) Refer Guide Book No 3, Chapter 3, Page No 94** **b) Refer Guide Book No 3, Chapter 3, Page No 95** **c) Refer Guide Book No 3, Chapter 3, Page No 97** **d) Refer Guide Book No 3, Chapter 3, Page No 93**
L-5	In a boiler, the forced draught fan develops a total static pressure of 300 mmWC. Determine the shaft power (in kW) required to drive the fan if 10,000 kg of coal is burnt per hour with 13 kg of air per kg of coal burnt. The boiler house temperature is 20 0C and static efficiency of the fan is 80 %. The operating air density may be calculated from the following: R = 847.84 mmWC m^3/kg mole K and Molecular weight of air, M = 28.92 kg/kg mole.
Ans	Total Pressure = 300 mm of WC Mass of air handled, m = 10000 × 13/ 3600 = 36.11 kg/s Atmospheric pressure, P = 1 kg/ cm2 = 10 mtr of WC = 10,000 mm of WC. Temperature T = 20 + 273 = 293 K Gas Constant for air, R = 847.84 mm WC m3/kg mole K Molecular weight of air, M = 28.92 kg/kg mole Density, kg/m3 = (P x M) / (R X T) = (10000 x 28.92) / (847.84 x 293) = 1.164 kg/m^3 Volume in m3/s = mass (kg/s) / density (kg/m3) = 36.11 / 1.164 = 31.02 m^3/s Power to fan shaft, kW = [Volume (m3/s) x Total pressure (mm of WC)] / [102 x fan efficiency] = [31.02 x 300] / [102 x 0.8] = 114 kW

L-6	A food processing plant has a contract demand of 2500 kVA with the power supply company. The average maximum demand of the plant is 2000 kVA at a power factor of 0.95. The maximum demand is billed at the rate of Rs.300/kVA. The minimum billable maximum demand is 75 % of the contract demand. An incentive of 0.5 % reduction in energy charges component of electricity bill are provided for every 0.01 increase in power factor over and above 0.95. The average energy charge component of the electricity bill per month for the company is Rs.10 lakhs. The plant decides to improve the power factor to unity. Determine the power factor capacitor kVAr required, annual reduction in maximum demand charges and energy charge component. What will be the simple payback period if the cost of power factor capacitors is Rs.800/kVAr ?
Ans	

kW drawn	2000 x 0.95 = 1900 kW
Kvar required to improve power factor from 0.95 to 1	kW (tan θ1 – tan θ2)
	kW (tan (cos-θ1) – tan (cos-θ2)
	1900 (tan (cos-0.95) – tan (cos-1)
	1900 (0.329 - 0)
	625 kVAr
Cost of capacitors @Rs.800/kVAr	Rs.5,00,000
Maximum demand at unity power factor	1900/1 = 1900 kVA
75 % of contract demand	1875 kVA
Reduction in Demand charges	100 kVA x Rs.300
	Rs.30000 x 12
	Rs.3,60,000
Percentage reduction in energy charge from 0.95 to 1 @ 0.5 % for every 0.01 increase	2.5 %
Monthly energy cost component of the bill	Rs.10,00,000
Reduction in energy cost component	10,00,000 x (2.5/100)
	Rs.25,000/month
Annual reduction	Rs.25,000 x 12
	Rs.3,00,000
Savings in electricity bill	Rs.6,60,000

Investment	Rs.5,00,000
Payback period	5,00,000/6,60,000
	0.76 years or 9 months

-------- End of Section - III --------