# Model Answer

**Winter – 2018 Examination**

**Subject & Code: Energy Conservation & Audit (17506)**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner should assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner should give credit for any equivalent figure/figures drawn.
5) Credits to be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer (as long as the assumptions are not incorrect).
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

**Model Answer**
**Winter – 2018 Examination**
**Subject & Code: Energy Conservation & Audit (17506)**

1A) **Attempt any THREE of the following:** **12**

1 a) State the meaning of energy conservation and its need in present scenario.

**Ans:**

**Energy conservation:**

Reduction in the amount of energy consumed in a process or system, or by an organization or society, through economy, elimination of waste, and rational use is referred as energy conservation. 1 mark

**Need of energy conservation in present scenario:**

i) Fossil fuels like coal, oil which have taken no. of years to form and now they are on the verge of depleting soon.
ii) In last 200 years we have consumed 60% of all energy resources.
iii) Today 85% of primary energy sources come from non-renewable and fossil sources. Due to rise in consumption, they are depleting very fast and future generations will not have any energy resources.
iv) Growth of industries and adaptation of advanced technology everywhere has increased the energy demand.
v) Swelling of population and rise in standard of living has also great effect on energy demand.
vi) Rate of growth in energy demand is more than energy generation rate.
vii) There is wide gap between generation and demand. And hence for sustainable development we need to adopt energy efficiency measures.
viii) Energy conservation also provides opportunity for environmental protection and integrated economic and social development.
ix) Energy saved is as good as energy generated.

1 mark for each of any 3 points = 3 marks

1A (b) Define the following term :

(i) Luminous flux
(ii) Illumination
(iii) Luminious Efficacy
(iv) Lux

**Ans:**

(i) **Luminous flux:**
It is the rate of flow of luminous energy and measured in terms of 'lumen'.

(ii) **Illumination :**
It is defined as the luminous flux (lumens) falling on unit area of the given surface on the working plane. The unit of illumination is lumen/$m^2$ or lux.

(iii) **Luminious Efficacy:**
This is the ratio of luminous flux (lumen) emitted by a lamp to the power (watts) consumed by the lamp. Unit is Lumens per watt.

(iv) **Lux:**
It is defined as luminous flux falling on unit surface area perpendicular to the flux. 1lux = 1 lumen/$m^2$.

1 mark for each definition = 4 marks (Units are optional)

1A (c) Describe the need of energy conservation in Induction motor.

**Ans:**

**Need of energy conservation in Induction motor:**

i) Induction motors are used as electrical drives in industrial, commercial and

residential sectors.

ii) Considering all industrial applications, 70% of total electrical energy is consumed by only electric motor-driven equipment**.**

iii) Half of total energy consumed by any equipment in any application is used by motors.

iv) Induction Motor's efficiency is maximum at full load only and on an average of 80 % to 85%. For load less than 30%, efficiency is very poor.

v) Induction motor works with poor power factor (less than 0.85) at full load and less than 0.35 at low load condition.

vi) Induction Motor draws high starting current and hence creates voltage drop in supply line, which affects performance of other apparatus connected to the same system.

vii) Induction motor also needs lagging reactive power which is required for its working; hence it also acts as reactive power load on supply system.

viii) To adopt advanced technology in design and to use better quality materials

1 mark for each of any four points = 4 marks

1 A (d) State any two opportunities for energy conservation techniques in transformer.

**Ans:**

**Opportunities for energy conservation techniques in transformers:**

i) Use of energy efficient transformer.

ii) Use amorphous core containing ferromagnetic elements like iron, cobalt alloy. This material has high resistivity than silicon steel. Due to this core losses are reduced so less energy wasted.

iii) Use encapsulated dry type transformer.

iv) Use tapped transformer, usually auto transformer leading to saving in copper.

v) Use thinner laminations of superior CRGO steel in transformer core to reduce iron losses.

vi) Carry out periodic maintenance of transformer.

vii) Use better quality low resistance copper conductors to reduce copper losses.

viii) Maintain operating voltage and frequency at the rated values (power quality) so that losses are minimized.

ix) Use better quality insulation materials to improve overload capacity and decrease dielectric leakages.

2 mark for each of any two points = 4 marks

**1 B Attempt any <u>ONE</u> of the following: 6**

1 B (a) Describe the procedure for assessing existing lighting system in a facility.

**Ans:**

**Procedure for Lighting System Assessment:**

1. <u>Room index:</u> Calculate the room index in order to determine no. of points and their positions where measurements are to be carried out.

   Let $L_i$ – Length of interior,

   $W_i$ – Width of interior.

   $H_m$ – Height of the lighting fitting above the horizontal working plane.

   The room index is calculated as

$$RI = \frac{L_i \times W_i}{H_m(L_i + W_i)}$$

Stepwise procedure 6 marks

2. Finding out the installed load efficacies
   Step1: Measurement of the floor area of interior, Area = ---------- $m^2$
   Step 2: Determine Room index
   Step 3: Measure the total circuit watts of the lighting installation using power meter
   Step 4: (Value obtained in step 3) / (Value obtained in step 1)
   Total circuit watts / floor area = ---------- w / $m^2$
   Step 5: Find out the average maintained illuminance using Lux meter.
   Step 6: (Value obtained in step 5) / (Value obtained in step 4)
   Step 7: Get target Lux/w/$m^2$ according to the type of interior or application and RI obtained in step in step 2
   Target Lux/w/$m^2$ = ----------
   Step 8: Installed Load Efficacy Ratio ( ILER )
   = (Value obtained in step 6) / (Value obtained in step 7)
   ILER = ------
3. Target Lux/w/$m^2$ for various premises :- The amount of light required is an important factor to perform a particular task or to illuminate the workspace. The most effective lighting with respect to performance and cost needs to have detail knowledge of the premises or application for which it is to be installed. The primary requirement of lighting as well as quality and amount of illumination depend upon,
   1. Nature of industry
   2. Its ocular needs & personnel
4. Assessment of ILER using indicators of performances :- Annual energy wastage is possible to calculate after deriving the actual ILER as:
   Annual energy wastage (kwh)
   = (1- ILER ) × Total load ( kw) × annual operating hours (h)
   Efficiency of the new lighting installations or replacement can also be assessed by comparison of ILE with target value for RI and type. In this case if the calculated ILE is found less than the target value, it is suggested to diagnose the reasons.

1B (b) Describe the following energy conservation methods of electrical motors :
   i) Matching motor
   ii) By operating in star mode

**Ans:**

**(i) Matching motor:**

i) Industrial motors frequently operate under varying load conditions due to process requirements. A common practice in cases where such variable-loads are found is to select a motor based on the highest anticipated load.

3 marks

ii) In many instances, an alternative approach is typically less costly, more efficient, and provides equally satisfactory operation. With this approach, the optimum rating for the motor is selected on the basis of the load duration curve for the particular application. Thus, rather than selecting a motor of high rating that would operate at full capacity for only a short period, a motor would be selected with a rating slightly lower than the peak anticipated load and would operate at overload for a short period of

time.

iii) The operation within the thermal capacity of the motor insulation is of greatest concern in a motor operating at higher than its rated load, the motor rating is selected as that which would result in the same temperature rise under continuous full-load operation as the weighted average temperature rise over the actual operating cycle. Under extreme load changes, e.g. frequent starts / stops, or high inertial loads, this method of calculating the motor rating is unsuitable since it would underestimate the heating that would occur.

iv) Where loads vary substantially with time, in addition to proper motor sizing, the control strategy employed can have a significant impact on motor electricity use. Traditionally, mechanical means (e.g. throttle valves in piping systems) have been used when lower output is required. More efficient speed control mechanisms include multi-speed motors, eddy-current couplings, fluid couplings, and solid-state electronic variable speed drives.

**(ii) Operating in star mode:**

i) Lesser than 30% load means torque required by load is less than 30%. Hence current requirement is reduced.

ii) When connected in star, the phase voltage reduces to $(1/\sqrt{3})$ times that in delta mode. As the torque generated by motor is directly proportional to the (applied voltage per phase)$^2$ the torque produced falls to 1/3 compared to delta mode.

iii) Due to decreased phase voltage, the iron losses decrease to nearly 1/3, as total iron losses are proportional to (applied voltage per phase)$^2$ before saturation.

iv) Due to reduction in phase voltage the current drawn in the lines also reduces leading to lower copper losses in motor and decrease line losses.

3 marks

2 **Attempt any <u>FOUR</u> of the following:** **16**

2 a) State the criteria for lamp replacement with energy efficient lamps and of light control gear as a energy conservation technique.

**Ans:**

**Energy conservation methods of lighting system:**

**i) By replacement with energy efficient lamps:**

- Installation of energy efficient compact fluorescent lamps in place of "Conventional" fluorescent lamps.
- Installation of metal halide lamps in place of mercury / sodium vapour lamps.
- Installation of High Pressure Sodium Vapour (HPSV) lamps for applications where colour rendering is not critical.
- Installation of LED panel indicator lamps in place of filament lamps etc.

½ mark for each of any four = 2 marks

**ii) Using light control gears:**

- The simplest and the most widely used form of controlling a lighting installation is "On-Off" switch.

- Grouping of lighting system, to provide greater flexibility in lighting control (manual or automatic).
- Installation of microprocessor/ infrared controlled dimming or switching circuits.
- Advanced lighting control system uses movement detectors or lighting sensors, to feed signals to the controllers.
- Optimum usage of day lighting in combination with electric lighting.
- Installation of exclusive transformer for lighting. It will reduce the voltage related problems, which in turn increases the efficiency of the lighting system.
- Installation of high frequency (HF) electronic ballasts in place of conventional ballasts which saves energy up to 35%.

½ mark for each of any four = 2 marks

2 b) Draw and explain power flow diagram of Induction motor.

**Ans:**

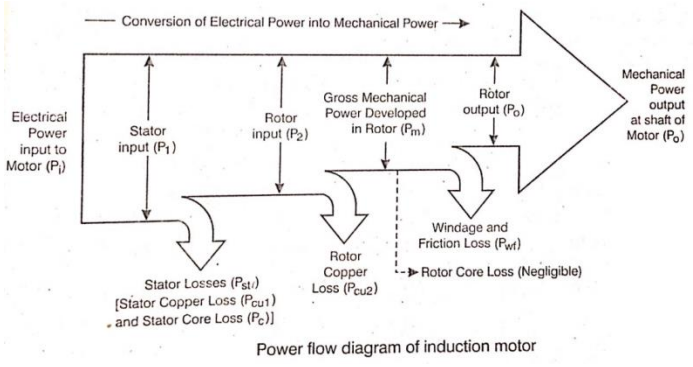
**Power flow in Three Phase Induction Motor:**

The electrical power input to the stator winding of an induction motor is transferred to rotor through the air gap between the stator and rotor by electromagnetic induction principle. This power is utilized to deliver the load at the shaft of motor and to supply $I^2R$ loss in the rotor. Out of total power input to stator, stator Cu loss and iron loss is supplied and remaining power then transferred as power input to rotor. Since rotor rotates at speed near to synchronous speed, the rotor core is subjected to reversal of magnetic field at very low frequency. Hence rotor core loss is negligibly small. If the gross torque developed by rotor is $T_a$ Nm and synchronous speed of rotating magnetic flux be $N_s$, then power transferred from stator to rotor $= \frac{2\pi N_s T_a}{60}$ synchronous watt.

2 marks for explanation

When the rotor rotates at a speed $N_a$ rpm, total mechanical power developed by rotor $= \frac{2\pi N_a T_a}{60}$ watt

Hence (Power transferred from stator – mechanical power developed by rotor)
= rotor $I^2R$ loss



Power flow diagram of induction motor

2 marks for block diagram

2 c) State the need of energy conservation in transformer and material used to improve the design & performance of transformer.

**Ans:**

**Need of energy conservation in transformer:**

In electrical power system, transformers are used to change the voltage levels of different sections as per the need of economic and efficient operation of the system.

2 marks

Since the transformers are integral part of power system and large in numbers, whether they are on load or no load, they always remain on line.
The power losses in windings (no load primary copper losses due to no load current) and in magnetic core (due to rated voltage across primary) results in energy wastage.
As rated voltage and no load current are there around the clock, reduction in these losses in transformer leads to large amount of energy savings over the period, which can be used for some other good reason. Therefore, there is need of energy conservation in transformer.

**Material used to improve the design & performance of transformer:**

(i) Amorphous metal or amorphous steel
(ii) Epoxy Resin
(iii) Polyester sealent
(iv) Cast Resin
(v) Metglass

1 mark for each of any two materials = 2 marks

2 d) List out the different technical losses that take place in transmission and distribution system.

**Ans:**

**Technical losses that takes place in Transmission and Distribution System**:

i) Copper losses
ii) Loss due to unbalance loading
iii) Copper loss due to long length of distribution lines
iv) Copper loss due to conductor of inadequate size
v) Various losses in transformer
vi) Losses in Long lines between transformer and load center
vii) Loss due to Low power factor
viii) Loss due to Load factor
ix) Reactive power loss
x) Loss at Improper joints and connection.

½ mark for each of any 8 losses = 4 marks

2 e) State any four objectives of tariff system.

**Ans:**

**Objectives of tariff system:**

i) Recover judiciously and legally capital investment made on electricity generation, transmission & distribution.
ii) Recover judiciously and legally the cost of operation, supplies, maintenance & losses incurred.
iii) The costs incurred must be judiciously distributed amongst the consumers.
iv) Cost of metering, billing, collection & miscellaneous services must be recovered.
v) Encourage the consumers for using power during the off peak hours so that load factor is maintained high.
vi) Discourage users from drawing higher loads than contracted.
vii) Should have a provision of penalty for low power factor and incentive for high power factor.
viii) Gain a suitable profit on the capital investment.

1 mark for each of any four objectives = 4 marks

2f) State the term co-generation and explain its significance.

**Ans:**

**Co-generation:** A co-generation system is a single, integrated system in which many forms of useful energy are simultaneously generated, mostly electrical, mechanical and thermal using single source of fuel. — 1 mark

**Significance of Co-generation:**

i) In conventional power plant efficiency is only 35% and remaining 65% of energy is lost.
ii) The conventional system uses energy of fuel to produce electrical energy or thermal energy whereas co-generation system produces both electrical and thermal energy from both fuels.
iii) The overall efficiency of energy use in co-generation can be up to 85% or above.
iv) Lower volume of $CO_2$ compared to the conventional system where separate production of electricity and heat.
v) In Co-generation system, heat generated is byproduct in electricity generation process.
vi) Limited need of cooling water in co-generation system therefore reduces thermal pollution.

1 mark for each of any three points = 3 marks

3 **Attempt any <u>FOUR</u> of the following**: **16**

3a) State the advantages of installing high frequency electronic ballasts in place of conventional ballast in case of lighting system.

**Ans:**

**Advantages of installing high frequency electronic ballast in place of conventional ballast in case of lighting system:**

i) Instant light.
ii) Lighter in weight.
iii) Power saving is up to 35%
iv) Heat output is negligible, that reduces load on air conditioning.
v) Improved power factor.
vi) Operates at low voltage.
vii) Enhances life of lamp.

1 mark for each of any four advantages = 4 marks

3b) State the factors governing the selection of induction motor.

**Ans:**

**Factors governing the selection of Induction motor:**

i) Load torque required at normal speed matches with available torque of motor.
ii) Break down torque or pull out torque or maximum torque must match with the maximum torque requirement by load.
iii) Starting torque of motor must be more than that needed by load.
iv) The duty or load cycle of the motor determines the motor's thermal loading, hence it should be such that sufficient time is available for cooling between the cycles.
v) The torque speed characteristics available from the motor must match the requirements of the load.
vi) The environment/atmosphere in which the motor is to be installed govern the motor operating characteristics. e.g. Corrosive atmospheres,

½ mark for each of any eight factors = 4 marks

dusty atmospheres, high temperature spaces need properly chosen motors for drives.

vii) Cost of the motor plays an important role if a range is available.

viii) Easily procurable, quick and easily serviceable motors are normally preferred. Standard motors are normally preferred.

ix) Normally while selecting motors, its performance is verified from the test certificate.

x) The power factor (reactive power drawn) and performance between 70% load to 100% load are considered. A motor having good characteristics in this regards will be always be preferred.

xi) For selecting energy efficient motor, the cost benefit analysis over the long run must be worked out.

3c) State the various commercial losses in transmission & distribution system. Also state energy conservation techniques adopted for reducing the losses takes place in transmission and distribution system.

**Ans:**

**Commercial losses in transmission & distribution system:**

1) Make unauthorized extension of loads. (Direct Hooking)
2) Errors in meter reading & recording (faulty meter).
3) By passing the meter. (unmetered supply & unmetered bills)
4) Improper testing & calibration of meters.
5) Stopping the meters by remote control.
6) Changing the sequence of thermal wiring.
7) Changing the C.T. ratio.
8) Intentional burning of meters.

½ mark for each of any four advantages = 2 marks

**Energy conservation techniques adopted for reducing the losses takes place in transmission & distribution system:**

1) Find out the weakest area of more technical/commercial loss in the distribution system.
2) Installation of the distribution transformer near the load centre.
3) Proper selection of capacity of the distribution transformer .
4) Reduce the overload on the distribution transformer & if require install one more additional transformer.
5) Use energy efficient transformer in which amorphous core material is used.
6) Use shunt capacitor to reduce the reactive power demand.
7) Using the HVDC system for long distance transmission.
8) Using the ACSR/AAAC/Bundle conductor instead of solid conductor.
9) Regulation of the system voltage.
10) Reactive power compensation.
11) Power factor control.
12) Minimizing $I^2R$ losses.
13) Balancing load current.

½ mark for each of any four points = 2 marks

3d) Describe maximum demand tariff and power factor tariff.

**Ans:**

**Maximum Demand Tariff:**

It is similar to two part tariff except that maximum demand (KVA) is actually

measured by installing maximum demand meter (in KVA)

- Maximum Demand Tariff =

{M.D. in kVA × Rs 'X' } + {Number of units or KWH actually consumed × Rs 'Y'} 2 marks

Where, X = Rate in Rupees per kVA maximum demand.
Y = Rate in Rupees per unit of energy consumption.

**Power Factor Tariff :**

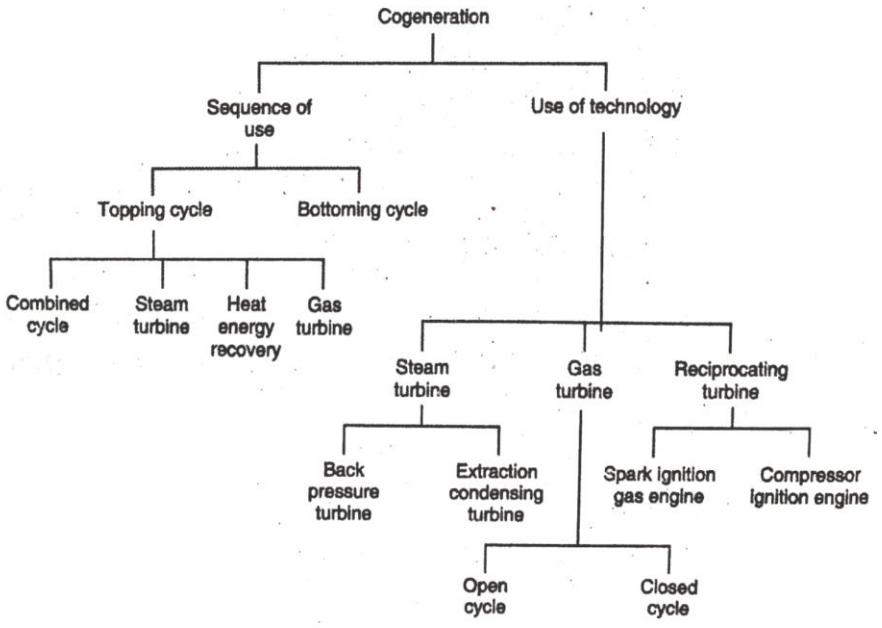
In addition to basic tariff (Maximum Demand Tariff / KVA Maximum Demand Tariff / Load factor tariff) the tariff in which P.F. of industrial consumer is taken into consideration is known as Power-factor tariff.

- If the P.F. of consumer is less than P.F. declared by Supply Company (say below 0.9 lag) then penalty will be charged in energy bill. 2 marks
- If the P.F. of consumer is more than P.F. declared by Supply Company (say above 0.95lag.) then incentive will be given in energy bill.
- As usual consumer has to pay actual energy consumption charges.

3e) Explain the classification of co-generation system on the basis of sequence of energy use and on the basis of technology.

**Ans:**

**Classification of co-generation system:**




Classification of Cogeneration Schemes

2 marks for the basis of sequence of use.

2 marks for the basis of use of technology

4 A) **Attempt any <u>THREE</u> of the following**: **12**

4 A) a) Explain amorphous core transformer and epoxy resin cast (dry type transformer) w.r.t. energy conservation.

**Ans:**

**Amorphous core transformer w.r.t. energy conservation:**

i) Amorphous core transformer is energy efficient transformer. The magnetic core is made up of amorphous metal. This core can be easily magnetized

and demagnetized.

ii) The amorphous alloy is made up of iron, boron, silicon alloy, molten metal mixture when cooled to solid state at a very high speed rate, retain a random atomic structure that is not crystalline. This amorphous resembles to glass so referred as glass metal.

iii) In case of amorphous core material, size of core, conductor, tank and insulating oil is increased.

iv) The amorphous material is 9 times harder than CRGO steel. Hardness, along with small thickness makes slitting and shearing process more difficult.

v) The amorphous material consists of high electrical resistivity and low field magnetization. Due to low field magnetization, hysteresis loss is low. Due to high electrical resistivity, eddy current loss is suppressed.

vi) Hence amorphous core transformer is approximately 20 to 30 % costlier than conventional core transformer.

½ mark for each of any four features = 2 marks

**Epoxy resin type or dry type transformer w.r.t energy conservation:**

**1. Epoxy resin impregnated:**

In this transformer, the polyster sealent is applied on transformer winding & the coils are poured in some chemical liquids & after it, it is dried in the oven. Due to this the winding resistance for corona increases and corona effect decreases. The high voltage sustained capacity increases. There will be more resistance to the moisture & due to epoxy resin impregnation there will be high temperature resistance. Due to all this, the losses in the transformer is less & efficiency of the transformer increases.

1 mark

**2. Cast resin impregnated:**

Basically the dielectic strength of the cast resin insulation is more than epoxy resin impregatition. It is equal to insulation level of transformer oil. The overload capacity of these transformers is more. The lighting surges caused due to any reasons affect minimum to these cast resin transformers.

1 mark

4 A) b) Explain the following energy conservation techniques in transmission and distribution system:

(i) By reducing $I^2R$ losses

(ii) By compensating reactive power flow

**Ans:**

**Energy conservation techniques in transmission and distribution system:**

**(i) By reducing $I^2R$ losses:**

i) Find out the weakest area of more technical loss in the distribution system so as to implement the energy conservation techniques.

ii) Locate distribution transformer near to the load centre.

iii) Use proper capacity distribution transformer.

iv) Use energy efficient transformers.

v) Use HVDC system for long distance bulk power transmission.

vi) Use ACSR or bundled conductors instead of solid conductors.

vii) Reduce overloads on distribution transformer.

viii) Use power factor controlling devices or techniques.

ix) Minimize $I^2R$ losses.

x) Balance the load currents.

½ mark for each of any four techniques = 2 marks

xi) Regulate the system voltages.

**(ii) By compensating reactive power flow:**

i) The reactive power drawn through lines due to heavy reactive loads leads to increase in the kVA and higher current in lines.
   a. This current leads to higher line heating losses, heavy line voltage drops and fall in line efficiency.
   b. If this reactive power is compensated near the load ends, the current gets reduced thus decreasing the line losses and lowering the line voltage drops.
   c. The compensation also helps to supply higher loads as per the system capacity.

ii) There are reactive power compensation devices as capacitor banks and static VAR compensators that are used to carry out the compensation. Both lagging and leading reactive powers are compensated.

1 mark

1 mark

4 A) c) State the factors to be considered for selection of co-generation techniques.

**Ans:**

**Factors to be considered for selection of co-generation techniques:**

i) Heat power ratio should match the characteristics of cogeneration system.
ii) Load pattern: For selection of cogeneration system, the type of load, its continuity is very important aspect.
iii) Type of fuel: Generally the type of fuel is selected according to cost. The cost of fuel should be less.
iv) The quality of thermal energy: The quality of steam is decided by temperature & pressure of the steam.
v) Electricity buyback: Sometime the electrical energy generated in cogeneration system is sold out to supply company, after that whenever that factory is need of electrical power, it is purchased from supply company by common electricity buyback agreement.
vi) Grid dependent & independent system technology: There are various technology systems applicable for grid.
vii) Local environment regulations: In this regulation for cogeneration system we have to study all environmental conditions, politics & other regulation factors also.
viii) Base electrical load matching: By cogeneration system the minimum electricity demand should be supplied.
ix) Electricity load matching: It is the stand alone system or it is totally independent system in which the 100% electrical energy is achieved by the cogeneration system.
x) Base thermal load matching: The minimum thermal energy can be achieved by our cogeneration system & if required for additional thermal energy can be generated from purchased power of supply company or grid system.
xi) Thermal Load matching: In these system the 100% thermal energy is achieved by cogeneration system.

½ mark for each of any eight techniques = 4 marks

**Model Answer**
**Winter – 2018 Examination**
**Subject & Code: Energy Conservation & Audit (17506)**

4 A) d) What is energy conservation equipment and list out energy conservation equipment related to lighting system and induction motor.

**Ans:**

**Energy Conservation Equipment**:

The equipment which saves energy by optimally controlling the usage of the power, in the system is called as Energy Conservation Equipment. — 1 mark

**Energy conservation equipment related to Lighting System:**

1. Luxmeter
2. Power Analyzer
3. Voltage Stabilizer
4. Electronic Ballast
5. LED Lamp
6. Control gear or Regulators
7. Lighting transformer

½ mark for each of any three equipment = 1.5 marks

**Energy conservation equipment related to Induction Motor:**

1. Power factor Meter
2. Power Analyzer
3. Digital Voltmeter
4. Digital Ammeter
5. Wattmeter
6. Different types of starter

½ mark for each of any three equipment = 1.5 marks

4 B) **Attempt any <u>ONE</u> of the following.** **6**

4 B) a) A consumer has a maximum demand of 100 kW, p.f. 0.8 lagging and load factor is 60%. The tariff used is Rs. 75/kVA of maximum demand + 15 paise/kWh consumed. Calculate annual bill of consumer (considering 365 days/46)

**Ans:**

Given Data: M.D. = 100kW, p.f.= 0.8 Lag, L.F.= 60%=0.6,

Tariff is Rs. 75/kVA of MD, and rate p.u. = 15 paise/kWh

Units consumed /year: Max. Demand x L.F. x Hrs in years
= (100) x (0.6) x (365 x 24)
= 525600 kWh

Max. Demand in KVA = MD in kW/p.f.
= 100/0.8 = 125 kVA — 2 marks

Annual Bill = Max. Demand charges + Energy charges
= (75 x 125) + (15/100) x 525600
= 9375 + 78840 — 1 mark

Annual Bill = **Rs. 88,215/** — 2 marks

1 mark

4 B) b) An industrial plant has an incandescent load of comprising 100 nos. of 60 W, and 140 Nos. of 100 W. Calculate the energy savings and simple payback period if each incandescent load is replaced by 1x 40 W fluorescent lighting load. Lighting is required for 4000 hrs/yr and cost of electricity is Rs. 6.00/kWh. Replacement cost is Rs. 150/unit. Consider ballast consumption as 15 watt.

Given data: 100 W incandescent lamp = 2200 lumens
60 W incandescent lamp = 1320 lumens

( If lumens data is not considered, partially marks should be given if formulae &

40 W fluorescent lamp = 2400 lumens. procedure is correct)

**Ans:**

**Energy bill calculation before replacement**

Total load = (100 x 60) + (140 x 100) = 6000 + 14000 = 20000 watts = 20 kW

Bill = Load in kW x hours of use x Rate p.u. =20 x 4000 x 6 = Rs. 4,80,000/-

**Calculation of lumens output of old fixtures:** 1 mark

(140×2200)+ (100×1320) = 308000+132000 = 440000 lumen 1 mark

**Calculation of Number of new fixtures required:**

Number of 40W lamps required = $\frac{440000}{2400}$ = 183.33 ≅ 184 ½ mark

**Energy bill calculation after replacement**

Total load = 184 × (40+15) =184× 55 = 10120 watts = 10.12 kW

Bill = Load in kW × hours of use × Rate p.u.=10.12 × 4000 x 6 = Rs. 2,42,880/- ½ mark

**Energy Savings** = Energy bill before replacement - Energy bill after replacement ½ mark

**Energy Savings** =4,80,000 - 2,42,880 = **Rs. 2,37,120/-**

New Investment = No. of lamps × Cost of replacement ½ mark

= (184 x 150) = 2,7600/- ½ mark

Payback period = Investment/ Annual savings= 27600/ 237120

= **0.1164 year**

= 0.1164 ×365 ½ mark

= 42.486 ≅ **43 days** 1 mark

5 **Attempt any FOUR of the following** **16**

5a) What is phase balancing system? Explain how it is used to conserve energy in distribution system.

**Ans:**

**Phase balancing System :**

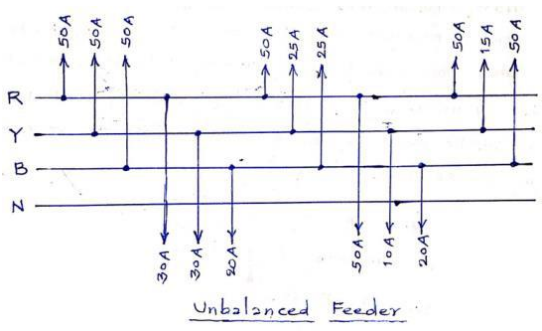
The phase balancing problem is formulated in the form of branch load balancing and system load balancing indices, where the branch load balancing index is used to measure the loading of a branch and the system load balancing index to measure the overall system loading. 1 mark

**Use of Phase balancing System conserve energy in distribution system:**

i) In India for distribution of electrical power, three-phase, 4 wire system is used.

ii) By using this system, three phase as well as single phase loads are supplied.

iii) Most of the three phase load is balanced but the single phase load will cause unbalance, depending upon the load used by consumer. 3 marks



Unbalanced Feeder

iv) Due to which there is a need of balancing single phase system and it is called as phase balancing system.

Figure shows single phase loads on three phase feeder at different points. A balanced load of 50 A is taken on each phase at the starting end of feeder. But at other points, the load is not balanced on all three phases. R phase is supplying 230 A, Y phase is supplying 125 A while B phase is supplying 165 A. Thus, the system is unbalanced in supplying loads on each phase. Due to which losses are increased. If proper care is taken to supply different phases such that equal or nearly equal load current is supplied by each phase, then the distribution system will be balanced and no additional losses will take place due to unbalance currents. To achieve this manually is difficult; therefore an appropriate optimization technique should be used.

5b) State incentives and penalty related with power factor.

**Ans:**

**Concept of incentive:**

When the value of consumer's average power factor of billing cycle is maintained above the value of reference power factor then the incentives (amount paid by energy supplier to consumer as a reward) are given to the consumer and electricity bill amount is reduced in proportion to the difference in power factor value above reference. — 2 marks

**Concept of Penalty:**

When value of consumer's average power factor of billing cycle is less than the value of reference power factor then the penalty is applied to the consumer and electricity bill amount is increased in proportion to the difference in power factor value below reference. — 2 marks

5c) State advantages of co-generation system and give the names of co-generation industries takes place in Maharashtra.

**Ans:**

**Advantages of co-generation system:**

1) Co-generation can meet both power & heat needs.
2) Less cost than conventional generation.
3) Higher system efficiency as energy wastage is highly reduced.
4) Reduction in emission of pollutants due to reduced fuel consumption.
5) A much more efficient use of primary energy can be achieved than with a separate production of electricity & heat.
6) In this system, heat generated is by-product in electricity generating process.
7) Due to decentralization of electricity supply it avoids transmission losses & makes system more flexible.

½ mark each of any four advantages = 2 marks

**Names of co-generation industries in Maharashtra:**

1) Urjankur Shri. Datta Power Company Ltd., (36 MW)
2) Urjankur Shri. Tatyasaheb Kore Warana Power Company Ltd., (44 MW).
3) Yashvantrao Mohite Patil Co-operative Sugar Factory (Satara) : 16 MW
4)Vitthal Co-operative Sugar Factory (Solapur): 10 MW
5) Sadashivrao Mandalik Co-operative Sugar Factory (Kolhapur): 12 MW
6) Doodhganga-Vedganga Co-operative Sugar Factory (Kolhapur): 20 MW
7) Samarth Co-operative Sugar Factory (Jalna): 18 MW
8) Sahakar Maharshi Shankarrao Mohite-Patil Co-operative Sugar Factory (Solapur): 33 MW

½ mark each of any four industries = 2 marks

**Model Answer**
**Winter – 2018 Examination**
**Subject & Code: Energy Conservation & Audit (17506)**
**Or any other industry having cogeneration in Maharashtra**

5 d) Describe the working of soft starter and state its advantages over conventional starter.

**Ans:**

**Working of soft starter:**

Soft starter delivers a controlled power to the motor to provide smooth, step less acceleration and deceleration. It consists of thyristor in main circuit and the motor voltage is regulated with a printed circuit board. So as the voltage is low at the time of starting, current & torque developed will be also low. During starting period the soft starter provides low voltage to motor which enables to adjust the play between the gear wheels or stretching driving belts or chains etc. In other words it eliminates unnecessary jerks during the start. Gradually the voltage and the torque increase so that the machinery starts to accelerate. The line voltage drops & losses at start are thus very low. It provides a reliable and economical solution to overcome problem related with starting. — 2 marks

**Advantages over conventional starter:**

1) Motor starts (without jerk) smoothly.
2) Severe spikes of starting currents are eliminated.
3) Loss of energy during starting is minimized to about 40 to 50%.
4) Severe wear and tear of mechanical parts such as bearing etc. during starting is eliminated leading to longer life of bearings and other related components.
5) Very low mechanical stress.
6) As starting currents are highly inductively limiting their magnitudes results in improved power factor.
7) As current peaks are controlled the MD is reduced which may lead to lower MD billing.
8) Less mechanical maintenance.
9) Saving in operating costs.

— ½ mark each of any four advantages = 2 marks

5 e) State the use of variable frequency drive with its advantages.

**Ans:**

**Use of Variable Frequency Drive:**

1. For conveyers, machine tools and other production line equipment machine starting and controlling
2. Tunnel boring, mining and oil drilling platform machines staring and controlling
3. For controlling motor driven centrifugal pumps, fans and blowers.

— 1 mark for each of any two uses = 2 marks

**Advantages:**

i) Energy saving due to optimum use for applications.
ii) Smooth starting can start the motor under load smoothly hence losses are avoided.
iii) Smooth speed control: Losses and shocks during speed control & speed changing -operations are avoided as smooth increase (to 300%) or decrease (to11%) of the rated speed is possible.
iv) Better process control, (with Micro controller and IGBT (Insulated Gate Bi-polar Transistor) optimization of input variables to get required outputs.
v) Less maintenance cost due to optimum working.

— ½ mark each of any four advantages = 2 marks

vi) Higher life span with very low losses for bearing & motors due to which we have improved optimal output power quality.

5 f) Define:
i) Energy Audit
ii) Simple payback period
iii) Return on investment
iv) ABC Analysis.

**Ans:**

**i) Energy Audit**

An energy audit is an inspection, survey and analysis of energy flows, for energy conservation in a building, process or system to reduce the amount of energy input into the system without negatively affecting the output(s). 1 mark

**ii) Simple Payback period**

It is the time required for an energy efficiency method to cover its purchase, installation and running costs. 1 mark

**iii) Return on investment (ROI)** measures the gain or loss generated on an investment relative to the amount of money invested. ROI is usually expressed as a percentage and is typically used for personal financial decisions, to compare a company's profitability or to compare the efficiency of different investments. 1 mark

The return on investment formula:

**ROI = (Net Profit / Cost of Investment) ×100**

**iv) ABC Analysis**

ABC analysis is the material management technique which helps energy audit process to achieve the goal of energy audit.

OR

ABC analysis provides a mechanism for identifying different categories of activities /stocks /items that will require different management and controls 1 mark

6 **Attempt any <u>FOUR</u> of the following** **16**

6 a) State the features of energy efficient motors as compared to conventional induction motor.

**Ans:**

**Features of energy efficient motors as compared to conventional induction motor:**

| Particulars | Energy efficient motor | Conventional induction motor |
|---|---|---|
| 1. Material used | They are manufactured with higher quality conducting, electromagnetic & insulating material & techniques | They are manufactured with lower quality conducting, electromagnetic & insulating material & techniques. |

1 mark for each of any four = 4 marks

| | | |
|---|---|---|
| 2. Losses | They usually have higher service factors & bearing lives, less waste heat output all of which increase reliability | High |
| 3. Starting torque | Good optimum value with soft starter | Depends on starting method |
| 4. Speed | Smooth speed over a required range & less vibrations | Speed may not be so smooth, jerks, vibrations may be involved |
| 5. Maintenance | Negligible maintenance, longer warranties, low failure rates | More maintenance, less warranty, High failure rates |
| 6. Operating temperature | Can withstand high temperature without any problem | At high temperature some problems may arise in the operation |

6b) Explain time off day and peak off day tariff.

**Ans:**

**Time off day:**

i) Time of Day (or TOD) tariff is a tariff structure in which different rates are applicable for use of electricity at different time of the day. It means that cost of using 1 unit of electricity will be different in mornings, noon, evenings and nights.

ii) Electricity is made expensive in peak demand hours so that consumer will prefer to not use electricity in that slot. 2 marks

iii) TOD tariff gives opportunity for the user to reduce billing. TOD energy meter is installed in the consumer premises. This meter is specially designed to measure energy consumption w.r.t. time.

iv) This type of tariff is such that energy consumption charges/unit are less at during Off load period. Energy consumption charges/unit are more during peak -load period.

v) This type of tariff is introduced to encourage industrial consumers to run their maximum load during Off-load period.

vi) The approximate TOD tariff is given:

| Sr.No | Block | Rate / KWH Rs | Remark |
|---|---|---|---|
| 1 | 8.00 am to 12.00 noon | Rs. 6.00 per unit+0.80 Rs. Per unit | Peak load period |
| 2 | 12.00 noon to 6.00 pm | Rs. 5.00 per unit+ 0 Rs. Per unit | Base load |
| 3 | 6.00 pm to 10.00 pm | Rs. 6.00 per unit+ 1.10 Rs. Per unit | Peak load period |
| 4 | 10.00 pm to 8.00 am | Rs. 5.00 per unit – 1.50 Rs. Per unit | OFF load period |

**Peak-off-day tariff:**

i) Energy consumption charges/unit are more during Peak -load period.

ii) This type of tariff is introduced to encourage industrial consumers to run

their maximum load during Off-load period.

iii) This tariff may not be suitable for all electric appliances but it is ideal for appliances such as water heating, pumping, refrigeration etc. 2 marks

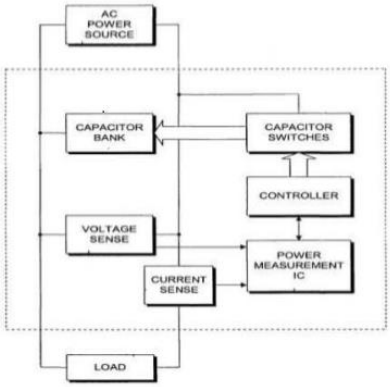
iv) The approximate tariff is given;

| Sr. No. | Demand period | Tariff |
|---|---|---|
| 1 | Off-peak hours | Less charges + Discount |
| 2 | Peak hours | More charges |

6 c) State the working principle and operation of APFC and MD controller used in transmission and distribution system.

**Ans:**

**Automatic Power Factor Controller (APFC):**




2 marks for APFC

The pf controller is used to maintain the pf at unity using capacitor bank across the line. It is controlled through microcontroller and contactor arrangement. Power factor of load is sensed and capacitors are connected / disconnected on the basis of KVAR demand. Maintaining the pf at unity leads to reduction in the current through the lines as Real power = apparent power x pf. The apparent power decides the MD for which the consumer is billed. The block diagram of the APFC is shown above.

The Supply main terminals are connected to input of APFC Panel. Power factor is sensed by the CT & PT placed in line side. As per the requirement the capacitor banks are operated to achieve calculated power factor by microprocessor based APFC relay. The appropriate capacitor bank will operate with respect to kVAR required to achieve target PF by APFC panel. After it CT & PT will check the feedback from the switching capacitors. Finally the required set power factor is achieved.

**Maximum Demand Controller (MDC):**

High –Tension (HT) users have to pay a maximum demand charge in addition to the usual charge for the number of units consumed. This charge is usually based on the highest amount of power used during some period during the metering month. The maximum demand often represents a large proportion of the total bill and may be based on only one isolated 30 minutes episode of high power use. Considerable saving can be realized by controlling power used and turning off or reducing non- essential loads during such periods of high power use. Maximum demand controller is a device design to meet the need of industries conscious of the value of load management. Alarm is sounded when demand approaches a preset value. If corrective action is not taken a controller

2 marks

switches off non-essential load. Demand control scheme is implemented using suitable control contactors so that the non-essential loads are automatically switched off.

6 d) State various energy audit instruments with their use of auditing.

**Ans:**

**Various energy audit instruments:**

1) **Flow meter:** Measures the rate of flow of fluids such as flue gases etc.
2) **Thermometers:** Measure the temperatures of enclosures, flue gases, fluids etc.
3) **Gas analyzer:** Analyzes gases such as flue gases, exhaust gases for their content of oxygen, carbon dioxide, carbon monoxide, nitrous oxides, sulphur dioxide etc.
4) **PH meter:** Measure the PH (acids and bases) value of solutions to give idea of their corrosion, polluting capacity etc.
5) **Voltmeters:** DC and AC wattmeter used for measuring the voltages at different points in electric systems.
6) **Ammeters** (AC and DC): Clip-on and direct connection types are used to measure the currents in different sections or branches of the electric system.
7) **Wattmeters:** To measure the electrical power.
8) **Trivector meters:** To measure multiple quantities such as kW, kVAr and energy consumed etc.
9) **Energy meters**: To measure the electric energy supplied to load continuously.
10) **Lux meters**: To measure the illumination level at required locations in lux.
11) **Meggers:** To measure the insulation resistance of machines and electrical equipment.

½ mark each of any eight = 4 marks

6 e) State the difference between "Walk through Audit" & "Detailed Audit".

**Ans:**

**Difference between "Walk through Audit" & "Detailed Audit":**

| Sr. No | Walk Through Audit | Detailed Audit |
|---|---|---|
| 1 | It is also called as the preliminary audit or screening audit or simple audit. | It is also called as general audit or site energy audit. |
| 2 | It is simplest, quickest and least expensive way. | It is nothing but expansion of the simple audit. |
| 3 | There are two resources:<br>i) Operation and maintenance staff collects the data.<br>ii) Serving utility provides this information. | In this method, the information of system operation is collected, but in more detailed form as compared to simple audit. |
| 4 | Basic information of the energy system in the premises is collected as well. | Auditor collects utility bills of an year to find out tariff structure, usage profile etc. |
| 5 | Only main issues are covered in walk through procedure. | This type of audit focuses all the most suitable energy conservation measures for the system. |

1 mark each of any four points = 4 marks