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

1 A) Attempt any THREE of the following: 12

1 A) (i) Explain the need of energy conservation in present scenario.

Ans:

Need of energy conservation in present scenario:

1. Fossil fuels like coal, oil which have taken no. of years to form and now they are on the verge of depleting soon.
2. In last 200 years we have consumed 60% of all energy resources.
3. 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.
4. Growth of industries and adaptation of advanced technology everywhere has increased the energy demand.
5. Swelling of population and rise in standard of living has also great effect on energy demand.
6. Rate of growth in energy demand is more than energy generation rate.
7. There is wide gap between generation and demand. And hence for sustainable development we need to adopt energy efficiency measures.
8. Energy conservation also provides opportunity for environmental protection and integrated economic and social development.
9. Energy saved is as good as energy generated.

Any 4 points 1 Mark for each point = 4 Marks

1 A) (ii) Explain the energy conservation technique adopted in Lighting system by
(a)Using most efficient luminaries.
(b)Using Light controlled gears.

Ans:

Energy conservation technique adopted in Lighting system:

a. Using most efficient luminaries :

- Optimum energy conservation can be obtained by using effective installation of luminaries along with lamps at proper height for achieving effective illumination.
- System layout and fixing of the luminaries play a major role in achieving energy efficiency. This also varies according to applications. For example, luminaries fitted with lamp should ensure that discomfort glare and viewing reflections are minimized.
- All incandescent lamps should be replaced by fluorescent/ CFL/LED lamps as per the application.
- All fluorescent lamps should be replaced by CFL/LED lamps as per the application.
- Better optical design of mirrors and quality of materials should be used for manufacturing of luminaries.

1 Mark for each point of any two = 2 Marks

b. Using Light controlled gears :

Energy conservation technique adopted in lighting system by using light controlled gears is as below:

- By proper grouping of lighting system, use of timer control, grouping of switch control etc minimizes manual errors leading to energy conservation. Such types of controllers are used in corridor lighting, go-downs, street lighting.
- Advanced lighting control system uses movement detectors, photo sensors ,

1 Mark for each point of any two = 2 Marks

audio sensors, occupancy-linked control, built-in time delay etc which feed signals to main ON OFF controller which makes lighting ON and OFF as per requirements. e.g.: Building lighting, garden lighting, workshops, street lighting etc.

- Nowadays in commercial buildings, malls, offices, more no. of lights are to be controlled and operational hours are also definite. In such type of applications, microprocessor based controllers are used which switch ON/OFF as per the working schedule. System can also be programmed month wise, year wise and even season wise.
- By using dimmers, the intensity of light can be controlled as per requirement.
  e.g Museums, Art galleries, Banks etc.
- If daylight alone is able to meet the illumination requirements, then the electric lighting can be turned off by using daylight linked control.

1 A) (iii) Compare energy efficient motor with standard motor on the basis of
(a) Starting torque
(b) Construction
(c) Energy conservation
(d) Efficiency

Ans:

Comparison of Energy Efficient motor with Standard motor:

Factor	Energy efficient motor	Standard motor
Starting torque	More than that of standard motor	Moderate
Construction	Core-CRGO material , Windings- copper conductors with larger cross section, Bearings-energy efficient bearings, Fan- aerodynamic designed fiber fan.	Core- silicon steel, Windings-aluminum conductors with smaller cross section, Bearings-standard bearings, Fan- standard fan of aluminum material.
Energy conservation	- Will satisfies energy conservation objectives, - complete more work per unit of electricity consumed, - Requires less maintenance	- Will not satisfy energy conservation objectives, -moderate performance consumes more power, - Requires periodical maintenance.
Efficiency	In the range 90-95%.	Generally in the range 80-85%.

1 Mark for each bit =4 Marks

1 A) (iv) Explain the following Energy conservation methods of electrical motor :
(a) Rewinding of motors
(b) Operating in star mode.

Ans:

Energy conservation methods of electric motor:

(a) Rewinding of motors:

i) During rewinding by preserving the original winding characteristics (material quality, design and structure). It is possible to maintain the original operating characteristics.
ii) Using larger cross section area of conductors and better insulation the copper losses can be minimized.
iii) Rewinding for the required torque and power or speed results in lowering of the losses (better efficiency and hence energy savings)
iv) Extension of coils beyond the slot insulation must be minimized to reduce the amount of copper used that leads to lowering of the copper losses.

2 Marks

(b) **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/√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(which is requires) 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.

2 Marks

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

1B) (i) State any six instruments used in energy audit procedure with their functions.

Ans:

Instruments used in energy audit procedure:

Instruments	**Functions in energy audit procedure**
Lux meters	Illumination levels on working area are measured in lux.
Contact thermometer	These are thermocouples, which measures temperature, for example flue gas, hot air, and hot water temperatures by insertion of probe into the stream. For surface temperature, a leaf type probe is used with the same instrument.
Infrared Thermometer	This instrument is useful for measuring hot spots in furnaces, surface temperatures etc.
Harmonic meter	Direct reading of %THD. Works with oscilloscopes as a harmonic and current transducer
Stroboscope / Tachometer	This is useful for speed measurements.
Load manager	This is used for measuring major electrical parameters such as kVA, kW, PF, hertz, kVAr, amps and volts.
Fuel Efficiency Monitor	This measures oxygen and temperature of the flue gas.
Fyrite	Fyrite can be used for O_2 and CO_2 measurement in the

½ Mark for name and ½ Mark for function of each of any six instruments = 6 Marks

	flue gases.
Leak Detector	This is Ultrasonic instrument used to detect leaks of compressed air / other gases
Pitot Tube & manometer	Air velocity in ducts can be measured using a pitot tube
Combustion analyzer	This instrument has in-built chemical cells which measure various gases such as O_2, CO, NO_X and SO_X

1B)ii)a) Explain the necessity of energy conservation in Electrical motors.

Ans:

Need of energy conservation in Electrical motors:

1. Induction motors are used as electrical drives in industrial, commercial and residential sectors.
2. Considering all industrial applications, 70% of total electrical energy is consumed by only electric motor-driven equipment**.**
3. Half of total energy consumed by any equipment in any application is used by motors.
4. 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.
5. Induction motor works with poor power factor (less than 0.85) at full load and less than 0.35 at low load condition.
6. 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.
7. Induction motor also needs lagging reactive power which is required for its working; hence it also acts as reactive power load on supply system.
8. To adopt advanced technology in design and to use better quality materials.

1 Mark for each point any three point = 3 Marks

1B)ii)b)Explain energy conservation technique in induction motor by improving mechanical power and transmission efficiency.

Ans:

Energy Conservation Technique in Induction Motor:

To improve the mechanical power and transmission efficiency, proper selection of belt drives and gear drives suitable for particular application is highly essential.

Belt Drives:

A well designed belt transmission offers:

- High efficiency
- Less noise
- Less maintenance
- No need of lubrication

1½ Marks for belt drives

Various energy saving and efficient belt types are:

1) V-belts:

- Trapezoidal cross-section improves the power transferability.
- Efficiency is about 90% at the time of installation and may drop by 5% over the time.
- Loose belts lower the efficiency, so retensioning is required from time to time.

2) Cogged belts:
- Slots running perpendicular to the length of belt provide reduced bending resistance of the belt.
- More efficient than V-belts.
- Longer life.
- Cooler as compared to V-belts.

3) Synchronous belts:
- Positive drive or high torque drive belts.
- Toothed structure with toothed drive sprockets on which they run.
- Efficiency about 98% is maintained over a wide load range.
- Less maintenance and retensioning
- Can operate in wet and oily environment
- Slip free run
- Suitable for high torque for which other belts become inefficient due to increased slippage.

Gear Drives:
- Helical and bevel gear drives are more efficient (90 – 95%), hence mostly preferred.
- Helical gears are opted for larger loads.
- Spur gears are avoided in new systems due to their low efficiency.
- Worm gears are available with greatly reducing ratios but have inconsistent efficiency. However, proves economical upto 15HP.
- Energy conservation is achieved by using more efficient gears for particular applications.

1½ Marks for gear drives

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

2a) State the recommended illumination level for each of the following situation.
(i) Living room (ii)Workshop
(iii) Godown (iv) Kitchen

Ans:

{**NOTE: illumination levels vary with area so marks should be awarded with proper discrimination**}

Recommended illumination:

Living room	General : 150 - 200 lux Task: 500 - 1000 lux
Workshop	General: 250 - 500 lux Task: 1000 - 2000 lux
Go- down	150-200 lux
Kitchen	General : 150 - 200 lux Task: 250 - 500 lux

1 Mark for each of any four points = 4 Marks

2b) State salient features of Energy conservation Act-2003

Ans:

Salient features of Energy Conservation Act-2003:

i) The Central Government to prepare a National Electricity Policy in consultation with State Governments.

ii) Thrust to complete the rural electrification and provide for management of rural distribution by panchayats, Co-operative Societies, non-government organizations, franchisees etc.
iii) Provisions for license free generation and distribution in the rural areas.
iv) Generation being delicensed and captive generation being freely permitted. Hydro projects need clearance from the Central Electricity Authority.
v) Transmission utility at the central as well as state level to be government company with responsibility for planned and co- ordinated development of transmission network.
vi) Provision for private licensees in transmission and entry in distribution through an independent network.
vii) Open access in transmission from the outset.
viii) Distribution licensees would be free to undertake generation and generating companies would be free to take up distribution businesses.

1 Mark for each of any four points = 4 Marks

2c) Define the terms:
(i) Lamp efficiency (ii) Luminous flux
(iii) Luminaire (iv) Colour Rendering Index.

Ans:

i) **Lamp efficiency or luminous efficiency:** It is the ratio of luminous flux emitted by a lamp to the power consumed by the lamp. It is a reflection of efficiency of energy conservation from electricity to light form. Unit is 'lumen / watt'.
ii) **Luminous flux :** It is the rate of flow of luminous energy and measured in terms of 'lumen'
iii) **Luminaire:** It is a device that distributes or transmits light emitted by one or more lamps. It includes all parts necessary for fixing and protecting the lamps, circuit's auxiliaries for connecting to supply. It works based on principle of reflection, absorption, transmission and refraction.
iv) **Colour Rendering Index (CRI):** It is a measure of the degree to which the colours of surfaces illuminated by a given source compare to those of the same surface under reference illuminant.

1 Mark for each definition = 4 Marks

2d) Explain energy conservation method in induction motor by improving power quality.

Ans:

Energy conservation method in induction motor by improving power quality:

Electrical energy can be conserved by improving the power quality. It can be achieved by avoiding voltage unbalance, maintaining voltage & frequency value and avoiding harmonic distortion.

1 Mark

i) Voltage unbalance:

Three phase induction motors are designed to operate on a balanced three phase A.C. Supply. In unbalanced condition the voltages in three phases are unequal which may cause a significant problem to motor such as excessive heating and vibrations. This condition leads to increase in the I2R loss in motor.

1 Mark

ii) Maintaining voltage & frequency value:

Maintaining the frequency and the required form factor of 1.11 (sine wave) minimizes the harmonics, and iron / mechanical losses as the speed is maintained at specified value. 1 Mark

iii) Harmonic distortion :

Increased use of the power electronics devices in the system leads to add the harmonics in a supply frequency. Undesirable effect of these higher frequencies related to the harmonic voltage distortion causes increase in iron and copper losses in motor. These losses can be minimized by using harmonic filter thus reducing the harmonics in the system. 1 Mark

2 e) State and explain the features of amorphous core transformers which results into energy conservation**.**

Ans:

Features of amorphous core transformers which results into energy conservation:

Sr. No.	Features of Amorphous core	Energy Conservation
1	The amorphous material saturates at 1.55 tesla	The operating flux densities are less, resulting low magnetic losses. However, the size of core, conductor, tank and insulating oil in case of amorphous transformer increases.
2	Thickness of amorphous metal is 0.025mm i.e.1/10 th of thickness of CRGO steel	Due to small thickness and low saturation factor, eddy current losses are reduced but larger core, larger coils and larger tank size are required for amorphous transformer.
3	The amorphous material possess high electrical resistivity	Due to high electrical resistivity eddy current is suppressed in amorphous transformers, resulting low eddy current losses.
4	The amorphous material possess low field magnetization.	Due to low field magnetization hysteresis loss is low in amorphous transformers.
6	This amorphous material has high permeability due to non-crystalline structure. It can be easily magnetized and de-magnetized	That reduces 70-80% of core losses in amorphous transformers.
7	As such core loss of amorphous metal alloys are reduced by 42% and magnetizing current by 53%	By using amorphous core, efficiency of transformer at low loads @38% is nearly 98.5%.

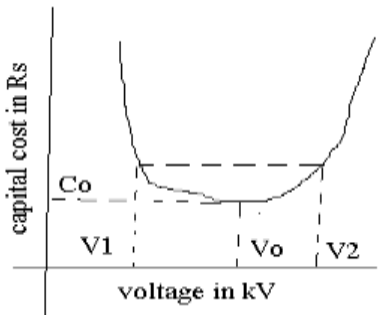
1 Mark for each of any four points = 4 Marks

2 f) Discuss how optimization of system voltage and balancing of phase current results into conservation of energy in transmission & distribution system.

Ans:

1. Energy conservation by optimization of system voltages (transmission system):

In transmission system, rise in voltage level improves the power transmission capacity. If voltage is increased by 'n' times, then the size of conductor reduces by $1/n^2$ times. Higher voltage involves higher cost of the system (cost of insulation, cost of switch gear, terminal apparatus etc.)



2 Marks

The relation between capital cost in Rs and standard line voltage in kV can be plotted and we get parabolic curve. The lowest point on the curve represents optimum voltage to be chosen. If capital cost does not differ appreciably, two voltages are selected (because higher V is easy to control than higher I). Optimum voltage for a system can be calculated by,

$$V_L = 5.5\sqrt{((L/1.6) + (P\times1000/\cos\phi \times NC \times 150))}$$

where, V_L = Transmission line voltage in kV
L = Length of line in km
P = Power to be transmitted
NC = Number of circuits
$\cos\phi$ =Power factor of load

2. Energy conservation by balancing of phase load / currents:

An unbalanced current produces 'Negative sequence' currents in the power system. This causes over heating of transformers, cables, conductors and motors. Negative phase sequence components create a rotating magnetic field in the stator which moves in the opposite direction. This causes a decrease in the resultant torque developed by the motor. The motor will thus have to draw a higher current for the same mechanical load. As a result losses are increased and unbalanced voltage condition is developed which leads to malfunctioning of motor. So it is necessary to keep the system negative phase sequence voltages within the limits. 2 Marks

As measure of energy conservation technique, the loads are distributed evenly among the phases. They can be separated as single phase loads and three phase loads by providing separate transformers. Similarly we can separate light loads and power loads with separate transformers. There is considerable amount of saving in capital (saving the de-rating of equipment) as well as energy losses.

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

3a) Write any four objectives of tariff system.

Ans:

Objectives of tariff system:

1) Recover judiciously and legally capital investment made on electricity generation, transmission & distribution.
2) Recover judiciously and legally the cost of operation, supplies, maintenance & losses incurred.

1 Mark for each of any four objectives = 4 Marks

3) The costs incurred must be judiciously distributed amongst the consumers.
4) Cost of metering, billing, collection & miscellaneous services must be recovered.
5) Encourage the consumers for using power during the off peak hours so that load factor is maintained high.
6) Discourage users from drawing higher loads than contracted.
7) Should have a provision of penalty for low power factor and incentive for high power factor.
8) Gain a suitable profit on the capital investment.

3b) State commercial losses in transmission and distribution systems. Also state the remedies for the same.

Ans:

Different commercial losses in transmission & distribution system:

1) Losses due to unauthorized extension of loads.
2) Losses due to errors in meter reading & recording.
3) Losses due to bypassing the meter.
4) Losses due to improper testing & calibration of meters.
5) Losses due to stopping the meters by remote control.
6) Losses due to changing the sequence of thermal wiring.
7) Losses due to changing the C.T. ratio.
8) Losses due to intentional burning of meters.

½ Mark for each of any four losses = 2 Marks

Remedies:

The losses can be reduced by: Installing summation meters for a group of customers to detect pilferage, fixing responsibility (on personnel) of the amount of power drawn and amount supplied by the agency personnel, installing accurate meters properly tested, resorting to regular testing/calibration of meters, conducting surprise raids/checks on consumers premises to detect theft or pilferage.

2 Marks for remedies

3c) For the tariff of Rs.125/kVA of maximum demand and 10 paise per unit consumed ; load factor = 50 %. Find overall cost/unit at (i) unity pf, (ii) 0.8 pf. Consider max demand = 1 kVA.

Ans:

Given:

Tariff = Rs. 125/kVA of maximum demand + 10 paise per unit consumed

Load factor = 50 %, M. D. = 1kVA

Monthly total charges/bill:

MD charges per month = $(MD\ kVA \times MD\ charges\ per\ kVA)$

= 1 x 125 = Rs. 125.00

Energy charges per unit = 10 paisa/kWh = Rs. 0.10/kWh.

Energy consumed in a given time period is = (average active power) x (hours)

Energy consumption charges per month:

= average demand(kW) x (monthly hrs) x (charges per kWh)

Average demand kW = (load factor) x (maximum demand) x pf.

The number hours in a month is = 24 x 30 = 720. 1 Mark

i) At UPF:

Average demand kW = (load factor) x (maximum demand) x pf.
= 0.5 x 1 x 1 = 0.5 kW.

Energy consumption per month:
= average demand(kW) x (monthly hrs)
= 0.5 x 720 = 360 kWh.

Energy consumption charges per month:
= (monthly energy consumed in kWh) x (charges per kWh)
= 360 x 0.1 = Rs. 36.00.

Total billing = MD charges + energy charges
= 125 + 36 = Rs.161.00

Overall cost per unit = (total bill) / (kWh for the month)
= 161 / 360 = Rs. 0.447 or 44.7 paise/kWh. 1 Mark

ii) At 0.8 pf:

Average demand kW = (load factor) x (maximum demand) x pf.
= 0.5 x 1 x 0.8 = 0.4 kW.

Energy consumption per month:
= average demand(kW) x (monthly hrs)
= 0.4 x 720 = 288 kWh.

Energy consumption charges per month:
= (monthly energy consumed in kWh) x (charges per kWh)
= 288 x 0.1 = Rs. 28.80. 1 Mark

Total billing = MD charges + energy charges
= 125 + 28.8 = Rs. 153.80 ½ Mark

Overall cost per unit = (total bill) / (kWh for the month)
= 153.8/288 = Rs. 0.534/kWh = 53.4 paise/ kWh. ½ Mark

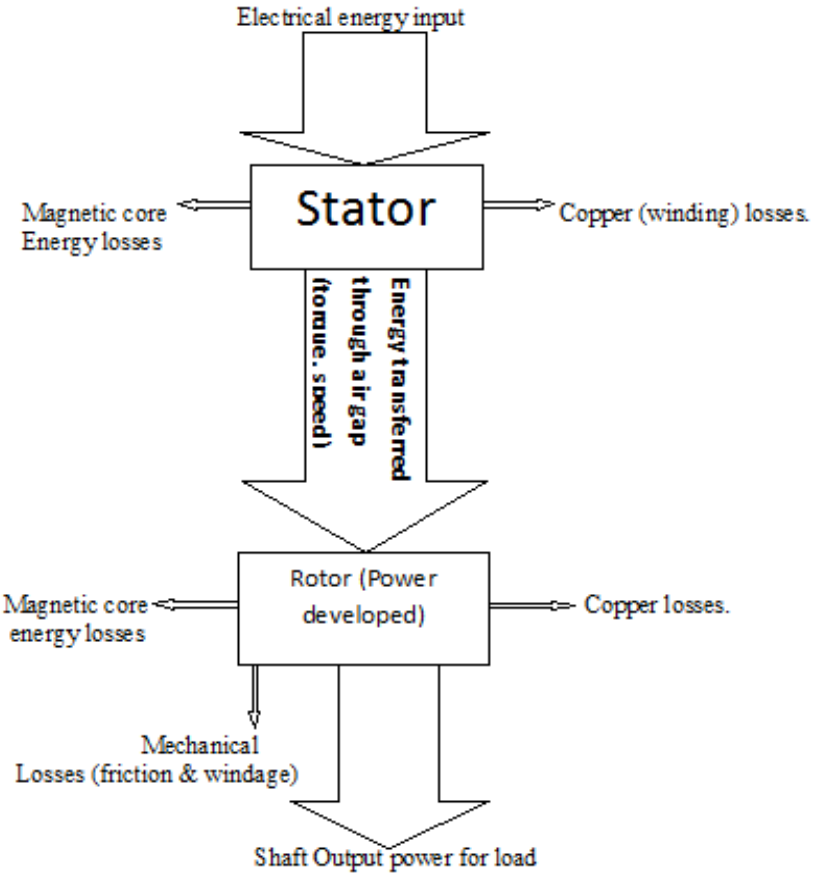
3d) Draw and explain power flow diagram of induction motor.

Ans:

Power flow diagram of induction motor:

1) Energy flow diagram is a graphical representation of the different power flow paths in which the width of the arrows are proportional to quantity of energy. Lengths of the arrows have no bearings with the quantities of energies.
2) These diagrams indicate the flow of energy in a process and help identifying the quality and quantity of energy.
3) The input of energy begins from top of the diagram. The outputs (useful

and leakages/losses of energy are shown on the diagram.



2 Marks for Labeled or equivalent diagram

1 Mark for Partial labeled diagram reduce marks proportionally

4) The Input is provided to stator. Two losses takes place in stator: Copper loss in stator winding and Core loss in stator core.
5) The remaining power is then transferred to rotor through air-gap and torque is produced on the rotor.
6) The rotor losses include: Rotor copper loss in rotor winding and negligibly small core loss in rotor core.
7) After supplying rotor losses, the remaining power appears as gross rotor output.
8) The frictional and windage losses take place at rotor body and bearings. The remaining power then appears as net rotor output mechanical power.

2 Marks for explanation

3e) State the opportunities for energy conservation techniques in transformers.

Ans:

Opportunities for energy conservation techniques in transformers:

Most of the energy loss that occurs in transformer is due to heat or vibration in the core that also reduces life of transformers. Regulatory Energy Commission (REC) has recommended that maximum efficiency of transformer must be maintained at 38% of loading condition of transformers. By using superior quality or improved grades of Cold Rolled Grain Oriented (CRGO) laminations, the no-load loss can be reduced to 32% than that specified by REC.

1 Mark

In conventional transformer, windings are made of copper material. Load loss depends on size of conductor. To make transformer more efficient, thicker

conductors are used so that load loss can be reduced.

Points to be covered:

1. Using energy efficient transformer.
2. Use amorphous core containing ferromagnetic elements like iron, cobalt alloy. This material has high resistivity than silicon steel. Due to this low core losses so less energy wasted.
3. Use encapsulated dry type transformer.
4. Use tapped transformer, usually auto wound leading to saving in copper.
5. Use thinner laminations of superior CRGO steel in transformer core to reduce iron losses.
6. Carry out periodic maintenance of transformer.
7. Use better quality low resistance copper conductors to reduce copper losses.
8. Maintain operating voltage and frequency at the rated values (power quality) so that losses are minimized.
9. Use better quality insulation materials to improve overload capacity and decrease dielectric leakages.

1 Mark each, any three points = 3 Marks

3f) Write any four merits of co-generation system.

Ans:

Merits 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.

1 Mark each merit of any four = 4 Marks (other valid points to be evaluated on merit)

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

4 A) i) Explain the role of adequate maintenance of lighting system in energy conservation.

Ans:

Role of adequate maintenance of lighting system in energy conservation:

Illumination level reduces due to accumulation of dirt on lamps and luminaries. Further as the lamps get older their light output gets affected.

- To prevent lamps and luminaries losing performance, and to maintain optimum light quality, protective glass panels and optical controls should be checked and cleaned regularly at least once in a month or at intervals depending on their location.
- Use pH-neutral (non acidic / non alcoholic) cleaning agents and lint-free cloths for cleaning.
- Use services of properly trained personnel to look after and work on large lighting systems.

- Replace not only defective luminaries, but also any luminaries whose luminous flux has diminished due to age.
- All the light control equipment must be inspected at least once a month for proper functioning by checking their input-output characteristics. These include lighting transformers, chokes, electronic control circuits etc.
- Any deviation from the expected standards must be addressed by proper corrective actions.
- As part of maintenance programme, periodic surveys of installation, lighting system with respect to lamp positioning and illumination levels, proper operation of control gears should be conducted to take advantage of energy conservation opportunities as user requirements change.

1 Mark for each of any four points = 4 Marks

4 A) ii) Explain parallel operation of transformer in context of energy conservation.

Ans:

Parallel operation of transformer in context of energy conservation:

The transformers operate near their maximum efficiency around 70 % to 100 % of their rated loads. For huge establishments drawing highly varying powers at different times supplying from single transformer will be uneconomical and inefficient as the efficiency varies. Because at light loads, a higher rated transformer has higher constant losses compared to a lower rated one. Also the allied systems for the transformers draw power thus reducing the overall efficiency. 2 Marks

Hence to operate the system at highest efficiencies as much as possible, parallel connected transformers are utilized such that at lower power requirements one of those with lower capacity (and hence lower power losses) in parallel will supply at around its maximum efficiency while the other is switched off thus saving its low load losses. This is done as per the requirements of the loads. 2 Marks

4 A) iii) Explain reactive power compensation in Transmission and Distribution systems.

Ans:

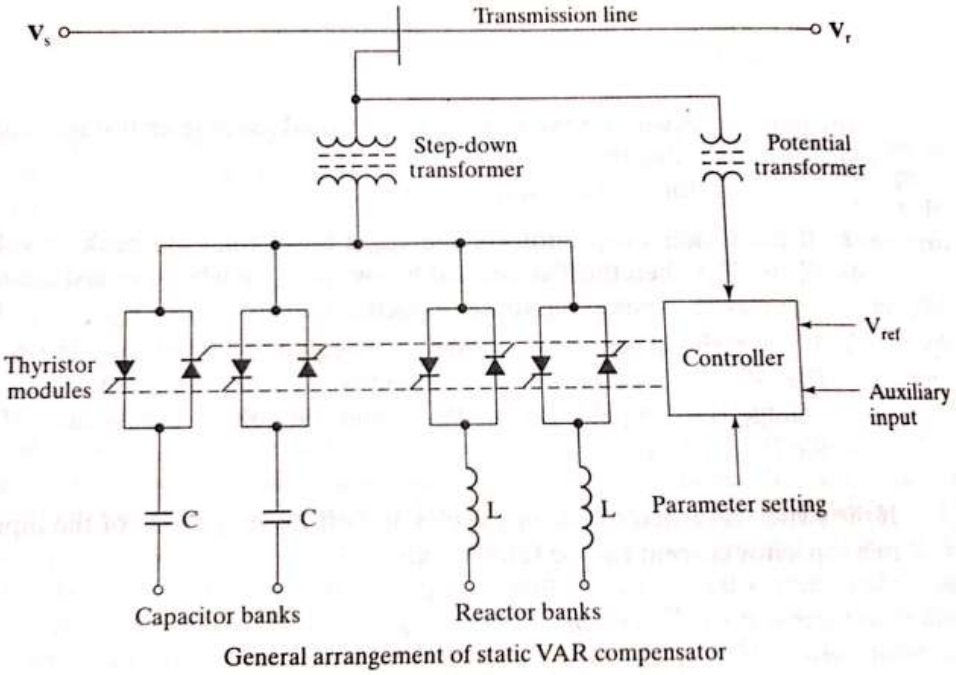
Reactive power compensation in Transmission and Distribution systems:

The reactive power is present in lines due to the reactive loads and device/ component reactances. This leads to heavy currents for active power transmission that result in overheating of transmission systems etc. and hence fall in the system efficiency.

Reactive power compensation leads to reduction of line/system current due to which the inherent current related power losses (I^2R) in the system are reduced, leading to increase in the system efficiency and improvement in the power quality. 3 Marks for explanation

Also as reactive power is compensated (leading to its reduction) the power factor is improved. Thus energy is conserved as the losses in the lines are minimized and the excess magnetizing current for increasing the voltage is avoided leading to savings.

Diagram shows a scheme of reactive power compensation used in transmission and distribution systems.



General arrangement of static VAR compensator

1 Mark diagram (other equivalent diagram to be evaluated on merit and correctness)

4 A) iv) State two benefits and applications of variable frequency drives.

Ans:

Benefits and applications of variable frequency drives:

The variable frequency drive helps to conserve electrical energy and gives the following benefits:

1) Energy saving due to optimum use for applications.
2) Smooth starting. Can start the motor under load smoothly hence losses avoided.
3) Smooth speed control: losses and shocks during speed control & speed changing operations are avoided as smooth increase (up to 300%) or decrease (to 11%) of the rated speed is possible.
4) Better process control, (with Micro controller and IGBT -Insulated Gate Bi-polar Transistor) optimization of input variables to get required outputs.
5) Less maintenance cost due to optimum working.
6) Higher life span with very low losses for bearing & motors due to which we have improved optimal output power quality.

1 Mark for each of any two benefits = 2 Marks

Applications:

1) Pumps used for fluids
2) Conveyers and transmission belts.
3) Machine tools operations.
4) Process control drives.
5) Textile industry machines.
6) Paper industry machines.

1 Mark for each of any two applications = 2 Marks

(other valid applications must be considered and evaluated on merit)

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

4 B) i) State the need of energy conservation equipment. Draw block diagram of

microprocessor based centralized control equipment of energy conservation and explain it.

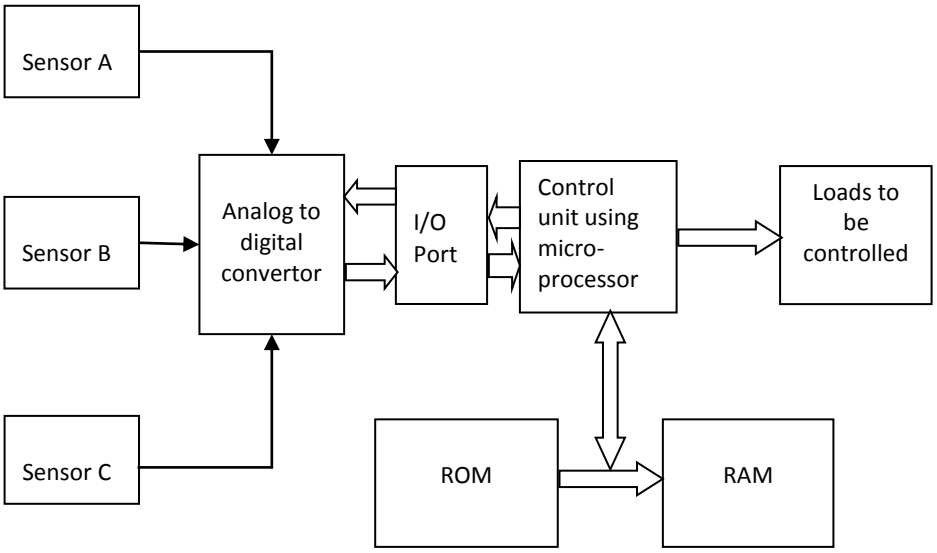
Ans:

Need for energy conservation equipment:

The energy conservation equipment is needed to properly implement (without affecting the promised quality/quantity) measures leading to saving in energy requirements by the systems. Properly implemented energy conservation measures using the correct equipment result in savings in energy, energy expenses and equipment expenses.

1 Mark for Need

Microprocessor based centralized control equipment of energy conservation:



Labeled Diagram 3 marks, (unlabeled or partially labeled reduced marking)

The sensors are employed to get the values/levels of quantities to be controlled. These sensors may be for position, temperature, light etc. The signals from the sensors are converted to digital form and fed to the microprocessor which determines the requisite actions needed for implementing energy conservation settings by fetching data for comparison from the ROM and carrying out internal actions for decision making by calculations/comparison using the RAM. The requisite signals are given to the control gear for controlling loads.

2 Marks

4 B) ii) Explain with flow chart the energy audit procedure.

Ans:

Energy audit procedure:

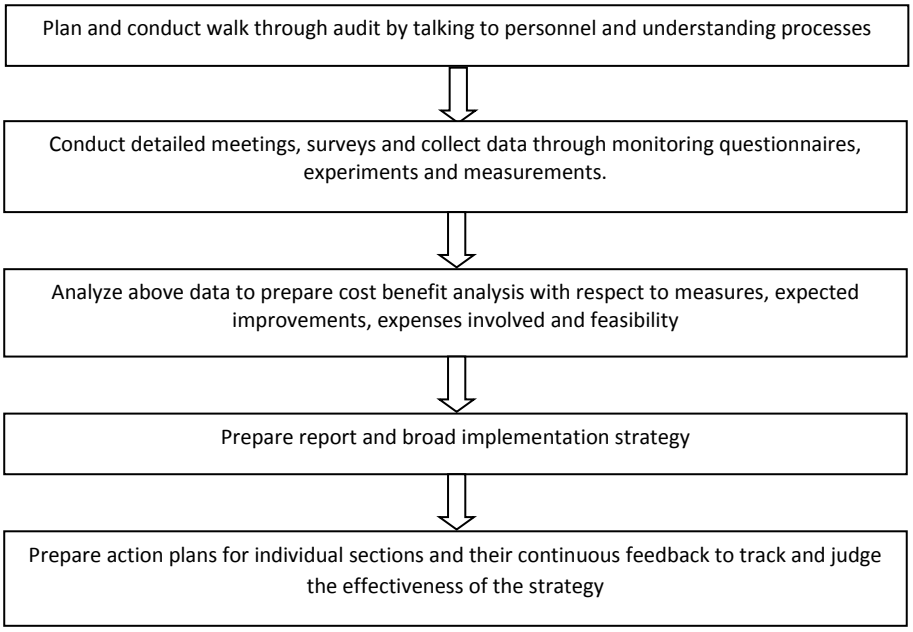
Energy audit is conducted in a following way:

- The planning of energy audit is decided by conducting meeting with working personnel in the industry.
- The complete information about the processes in industry is collected.
- Preliminary audit is carried out with the help of available data.
- Some experimentation, measurements, data collection and detailed survey and meetings are carried out.
- Cost benefit analysis considering payback period is done.
- Accordingly broad report is prepared for implementation of the strategy.
- The action plans are prepared for individual section, approved by the

3 Marks for explanation

authority.

- During implementation, the feedbacks are taken to judge the effectiveness of the strategy.



Properly labeled meaningful flow chart covering given actions = 3 Marks, else reduced marks proportionally

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

5a) Give classification of co-generation system on the basis of the use of technology.

Ans:

Classification of co-generation system on the basis of the use of technology:

i) Steam Turbine.
- a) Back pressure turbine.
- b) Extraction condensing turbine.

ii) Gas Turbine.
- a) Open cycle.
- b) Closed cycle.

iii) Reciprocating Turbine.
- a) Spark ignition gas engine.
- b) Compressor ignition engine.

4 Marks

5b) Explain scenario of transmission and distribution losses at national level.

Ans:

Scenario of transmission and distribution losses at national level:

i) T & D losses in India are the highest in the world. Inadequate investment in T&D network is one of the main reasons for high T & D losses in country.

ii) At present these losses in India are almost 25% in average but there is variation in the losses in different states.

iii) While considering scenario of T & D losses at National level it is necessary to consider geographical locations of different states.

iv) In some states like J&K these losses are as high as 58% in 2012.

v) In states like Uttarakhand, Manipur & Mizoram, Sikkim etc. these

1 Mark each of any four = 4 Marks

losses are higher up to 50%. Major contribution is of Technical loss due geographical locations.

vi) In states like Bihar commercial losses are higher i.e. up to 48%.

vii) The developed states like Gujrat, Maharashtra, Karnataka, the losses are about 25%. According to planning commission report, the target is to minimize these losses to 18% upto 2018.

5c) State ABC analysis related to energy audit.

Ans:

ABC analysis related to energy audit:

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

i) "A class inventory" contains items that account for 70% of total value.

ii) "B class inventory" contains items that account for 20% of total value. 4 Marks

iii) "C class inventory" contains items that account for 10% of total value.

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

5 d) Compare soft starter with conventional starter (any four point).

Ans:

Comparision of soft starter with conventional starter:

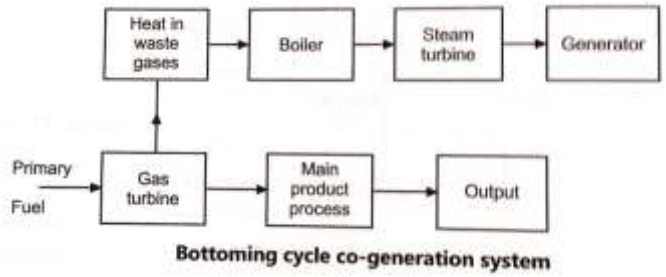
Sr. No.	Soft starter	Conventional starter
1	Smooth starting	Starting with small jerk
2	Low current peak	High current peak
3	Variable starting torque	Uncontrolled starting torque
4	Negligible voltage dip	Voltage dip causes of flickering of lights.
5	Energy saving	No energy saving
6	Almost maintenance free	More maintenance

1 Mark each for any four points = 4 Marks

5e) With diagram explain bottoming cycle type of co-generation.

Ans:

Bottoming cycle type of co-generation:



Bottoming cycle co-generation system

Diagram 2 Marks

i) Bottoming cycle of co-generation system is that in which high temperature heat energy is produced using primary fuels.

ii) This heat produced is mainly used for other processes except generation of electricity.

iii) Rejected heat from process is utilized to generate electricity.
iv) The rejected heat is taken from recovery boiler and it is then applied to the turbine connected to the generator to produce electricity.
v) From manufacturing process of some products heat at high temperature is required in furnaces and kilns.
vi) After the manufacturing process, the heat rejected or not utilized is also at significantly high temperature which cannot be neglected. And if neglected it will reduce the overall efficiency of the system greatly.
vii) Bottoming cycles are suitable for cement industries, ceramic factories etc.

Description 2 Marks

5f) Define the terms:
i) Tariff ii) Fuel surcharge
iii) Electricity Duty iv) Connected load

Ans:

i) Tariff:
The rate at which a consumer is charged for the consumption of electricity is called as tariff.

OR

The amount of money framed by the supplier for the supply of electrical energy to various types of consumers in known as an electricity tariff. In other words, the tariff is the methods of charging a consumer for consuming electric power. The tariff covers the total cost of producing and supplying electric energy plus a reasonable profit.

ii) Fuel surcharge:
It is amount that utilities apply on bills based on varying price of fuel or Coal. The price of coal or fuel changes every month based on demand and supply of coal and thus cost of producing electricity changes accordingly. The electricity generation companies pass on this cost to distribution companies who there by pass it on to consumers.

iii) Electricity Duty:
Electricity duty is charged on consumption and it is nothing but tax on electricity. It is mostly a rate that is applicable per unit of electricity consumed. In some states it is also applied as percentage of total charges (electricity usage + fixed charges) and in some states both are applicable.

iv) Connected load:
It is the total wattage of all appliances which are used by the consumer on his sanctioned connection.

1 Mark each = 4 Marks

6 Attempt any FOUR of the following: **16**

6 a) Discuss how power factor tariff results into energy conservation.

Ans:

Power factor tariff results into energy conservation:

i) Applying incentives and penalties according to power factor is an effective way, which enables consumer to improve power factor so that he can reduce his higher electricity bill.
ii) Incentive is given to those consumers who are charged on the basis of maximum demand and are provided with meters to measure their load power factor.
iii) When the average power factor of the consumer is more than 0.95, an

4 Marks

incentive at the rate of 1% of the amount of the monthly bill is given.

iv) When the average power factor of the consumer is 0.99 an incentive at the rate of 5 % of the amount of the monthly bill is given.

v) When the average power factor of the consumer is unity an incentive at the rate of 7% of the amount of the monthly bill is given.

vi) If power factor declines from 0.9, consumer is penalizes at the rate of 1 %. It is further increases with low power factor.

Thus motivating consumers for maintaining higher power factor will finally leads to reduction in the current drawn by the load and helps for energy conservation.

6 b) State name of eight industries suitable for co-generation of energy.

Ans:

Industries suitable for co-generation of energy: Any 8 industries = 4 Marks

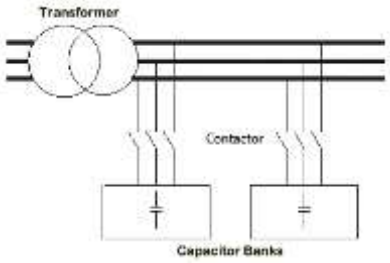
i) Sugar mills
ii) Rice mills
iii) Petrochemical Industry
iv) Distilleries
v) Cement Industry
vi) Pulp and paper industry
vii) Aluminum Industry
viii) National parks
ix) Wineries
x) Waste treatment plants

(Any Valid industries may please be considered)

6 c) Draw and explain bulk correction method for power factor & control.

Ans:

Bulk correction method for power factor & control: Diagram 1 Mark



i) Here individual starter controls the capacitors located at distribution panel.

ii) Centralized compensation is employed in large industrial plants where many motors are in use at a time.

iii) Capacitors racks are installed at the incoming distribution panel of the industry.

iv) These racks are subdivided into steps.

v) Current supplied to the distribution panel is monitored by the controller for power factor. Description 3 Marks

vi) Automatic control system switches subdivided rack of capacitor units in steps to maintain P.F. more than preset limit (0.95).

6 d) State the different types of tariffs. Explain any one.

Ans:

Different types of tariffs: 2 Marks

i) Simple tariff
ii) Flat rate tariff
iii) Block rate tariff
iv) Two part tariff
v) Maximum demand tariff
vi) Power factor tariff
vii) Three part tariff
viii) Time-of-Day (TOD) tariff

i) **Simple Tariff:** In this type of tariff, rate per unit is fixed. The rates will not vary with type of consumers, so it is very simple tariff to understand for consumers.

ii) **Flat rate Tariff:** In this type of tariff different types of consumers are charged at different rates i.e. the flat rate for light and fan load is less than that for power load.

2 Marks for explanation of Any one

iii) **Block rate Tariff:** This type of tariff uses a method of charging a consumer in blocks. Generally, block of first few units is charged at high rate, then next block of some units is charged at low rate and a third block of remaining units consumed by him is charged at still reduced rate. However in Maharashtra, the electricity board uses this type of tariff in the reverse manner so as to reduce the consumption of electricity for light and fan loads. It charges less for the first block and the rate increases for the succeeding blocks.

iv) **Two Part Tariff:** In this consumer has to pay his electricity bill, which consists of two parts. One part depending upon the maximum demand of the consumer and the other part consists of energy charges on the actual energy consumed.

$$\text{Total Energy charges} = a \times kW + b \times kWh$$

where a = Charge per kW of maximum demand

b = Charge per kWh or unit of energy consumed.

v) **Maximum demand tariff:** It consists of two parts i.e. Demand charge and Energy charge.

This system need a M.D. indicator to be installed at the premises of the consumer, hence such type of tariff is suitable to large and medium scale industries. It is also beneficial for electrical installations having high load factor. Exceeding the maximum demand over a sanctioned limit may cause penalty to consumer.

vi) **Power factor tariff:** In this tariff, Power factor of the consumer load is taken into consideration while charging the consumer for his electricity use. Low power factor consumer are penalized and high pf consumers are given incentives. Hence it is necessary that consumer be made to use electricity at high power factor otherwise he is charged more. There are three types of power factor tariff: kVA maximum demand tariff, Sliding scale tariff, kWh and kVAR tariff.

vii) **Three part tariff:** In this, total charges are divided into three parts namely, Fixed charge, Semi-fixed charge and variable charge.

$$\text{Total Energy charges} = a + b \times kW + c \times kWh$$

where, a = Fixed charge, consisting of interest and depreciation on the cost of distribution of energy and labour cost of official staff for collecting bills etc.

b = Charge per kW of M.D.

c = Charge per kWh of energy consumed.

This type of tariff is applied to the consumers having greater consumption.

viii) **Time-of-Day (TOD) Tariff:** Here the electricity charges are according to the time of day of energy usage. In peak hours, the rates are high and in non-peak hours, the rates are low. So that the consumers are encouraged to use the electricity during non-peak hours.

6 e) Discuss the role of replacement of old lamps by new more energy efficient lamps in the conservation of energy.

Ans:

Role of replacement of old lamps by new more energy efficient lamps in the conservation of energy:

i) Replacing incandescent lamps by Compact Fluorescent lamps: High wattage incandescent lamps are replaced by the low wattage CFL of same luminous output.

ii) Replacing conventional Fluorescent lamps by energy efficient lamps: High wattage conventional fluorescent lamps are replaced by the energy efficient lamps of same luminous output.

iii) Replacing Mercury/ Sodium Vapour lamps by Halide Lamps: High wattage Mercury/ Sodium Vapour lamps are replaced by the low wattage halide lamps of same luminous output.

iv) Replacing incandescent lamps by Fluorescent Lamps: High wattage incandescent lamps are replaced by the low wattage fluorescent lamps of same luminous output.

v) Replacing Filament/CFL lamps by LED: High wattage incandescent lamps/ CFL are replaced by the low wattage LED lamps of same luminous output.

1 Mark for each of any four points = 4 Marks

By these replacements, much more energy can be conserved.