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) State the importance and need of energy conservation in present scenario.
Ans:

The need for energy is always going to be there. As energy demand keeps on rising more of it in specified form needs to be generated.85% of Primary Energy Sources comes from fossil fuel and non-renewable energy sources. In last 200 years we have consumed 60% of all resources. Fossil fuels like coal, oil takes number of years to form through natural cycle. Because of rise in population, industrialization, change in life style, there is steep rise in energy demand. To meet these demands we have consumed maximum fossil fuel. Hence these fuels are on the verge of depleting soon. Up-till now more than 60% of all sources have been consumed. Rate of consumption of energy sources is more than that of formation. If rate consumption of energy increase similarly then no sources will be left over for next generation.

2 marks

Hence energy conservation is needed as it,
1) Reduces energy demand.
2) Reduces rise in energy cost.
3) Provides economical solution to energy shortages.
4) Increases financial capital.
5) Increases environmental value.

2 marks

1 A ii) Explain energy conservation method in lighting system by using installation of separate transformer servo stabiliser.
Ans:
Lighting circuits give the best performance when the supply voltage to them is of the rated value. Any deviation from the rated value results in either unnecessarily higher power drawn or under/inefficient performance in terms of lighting. To avoid this means are resorted to that maintain the voltage constant to such lighting circuits. The two main means are
1. Installation of a separate transformer for the lighting circuits and
2. Using servostabiliser.

1. Installation of a separate transformer for the lighting circuits:
   - Leads to nearly nil effect on lighting of load variations on the system voltage.
   - Longer life for lighting components as the harmful voltage variations are highly minimised to a great extent.
   - Lighting systems work with the highest efficiencies at the rated volatge.

2 marks

2. Using servo-stabiliser:
   - These are used when separate transformers are not economically feasible.
   - The lighting feeder voltage is maintained at the rated value by using the servo stabiliser that results in constant voltage to achieve a constant/optimum luminious efficiency and longer life of the lighting system components and minimum wastage of energy.

2 marks

1 A iii)Explain the following energy conservation methods of electric motors.

a) Matching motor rating with required load,   b) Rewinding of motor.

Ans:

a) **Matching motor rating with required load**: the motor matching with required loads is achieved in the following manners to maintain higher efficiency of the motors and conserve electric energy.

- When the required load differs much from the connected motor capacity it becomes necessary to replace the motor with the required load rating motor, as such operation leads to lower efficiencies and power factor (in under loading).

- Over sizing of motors by 50 % or more results in lower operating efficiency and lower pf. Also higher cost of motor means financial loss.

- Under sizing by 10% to 20 % or more results in heavy over loading due to which the motors run with heavy losses, overheating and lower efficiency finally leading to lower life.

- Also, the motor is operated in star mode for under loaded motors when the torque requirement is less compared to that at full load. Hence the voltage required at the motor winding is less due to less torque. In delta connection, line voltage is on each phase winding. When star connected, the current drawn by the motor drops significantly power factor increases and overall power saving is likely to be 10-20% depending on the extent of under loading.

2 marks

b) **Rewinding of motors:**

- During rewinding by preserving the original winding characteristics (materials quality, design and structure) it is possible to maintain the original operating characteristics.

- Using larger cross-section of conductors and better insulation the copper losses can be minimized.

- Rewinding for the required torque and power or speed results in lowering of the losses (better efficiency and hence energy savings).

- 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.

- Better cooling can be achieved by proper sized fans.

2 marks

1 A iv)State various instruments used in energy audit procedure with functions
Ans:

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: Analyze 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

1 mark each any four = 4 marks,

Students may list instruments other than

5) Voltmeters: DC and AC: used for measuring the voltages at different points in electric systems.

6) Ammeters (AC and DC): clip on and direct connection types. Measure the currents in different sections or branches of the electric system.

7) Wattmeters: measure the electrical power.

8) Trivector meters: measure multiple quantities as voltages, currents, kW, kVA, kVARh, TOD units, etc.

9) Energymeters: measure the electric energy supplied to circuits continuously.

10) Lux meters: measure the luminous intensity at required locations in lux.

11) Meggers: Measures the insulation resistance of machines and electrical components.

1 B	Attempt any one	6 marks

1 B   i) What is co-generation? Explain any five factors governing the selection of the co-generation system.
Ans:
Co-generation is production of power using the excess energy produced by a certain process (eg. Combustion) which is originally meant for a main process that produces products. Excess energy is wasted if not utilized for the co-generation.

1 mark

The factors that govern the selection of cogeneration systems are very much site/situation specific. The local factors such as the thermal energy requirements etc play an important role. Also the availability of the relevant opportunities and other related items decide the selection. They are broadly as follows:

1) Base electrical load matching: - The co-generation system is designed to meet the minimum electricity demand. The remaining power required is purchased from the utility grid.

2) Base thermal load matching: - The co-generation system is designed to supply the minimum thermal energy requirement. Stand by boilers/ burners are used if the demand for heat is higher.

3) Electrical load matching:- This is stand alone system. The co-generation system is designed such that total electricity required is generated. Therefore this co-generation system is totally independent of the electricity utility grid. Sometimes if energy demand is higher, auxiliary boilers are used.

4) Thermal load matching:- The co-generation system is designed such that the total heat energy require is generated. If required energy demand is higher electricity purchased from grid.

(right margin notes)
these for which the assessor has to make an intelligent evaluation and award marks.

1 mark each any 5 = 5 marks.

Other valid points may be considered

5) Availability of fuel: cheap and easy availability of fuel helps to achieve good co-generation.

6) Space requirements: the site if very limited in space does not support co-generation whereas ample space helps in installing the co-generation system

7) Initial and operating costs: lower values encourage the installation of co-generation systems.

1 B   ii) Explain working of automatic star delta convertor and state its advantages.
Ans:
Working of automatic delta to star convertor:
This is similar to the star delta starter the difference being in the mode of switching into star or delta. The rating of switching components must be properly selected as the star mode contactor will be in circuit continuously. Load sensor relay (motor current operated relay) senses the magnitude of load on the motor which actuates accordingly the connection of motor in star or delta. When the load on the delta connected motor falls below 40% the motor is switched to star mode thus operating near full load capacity of star mode. Similarly when the load rises to more than 110% of star mode capacity the motor switches to delta mode again operating with better efficiency.   3 marks

Advantages:
1) Higher operating efficiency.   Any 3
2) Savings in energy as copper losses get reduced due to reduction in current   points = 3
   when in star mode.   marks
3) Savings in energy as iron losses get reduced due to reduction in applied
   voltage when in star mode.
4) Intelligent utilization of motor capacity.

2   Attempt any four   16

2 a)   Write opportunities for energy conservation in transformer.
Ans:
Opportunities for energy conservation in transformer
1. Using energy efficient transformer
2. Use amorphous core containing ferromagnetic elements like iron, cobalt alloy.   Each point
This material has high resistivity than silicon steel. Due to this low core losses so   1 Mark any
less energy wasted.   four points
3. Use encapsulated dry type transformer.   = 4 marks
4. Use tapped transformer, usually auto wound for saving in copper.
5. Use thinner lamination in transformer core to reduce iron losses.
6. Adequate Periodic maintenance of transformer
7. Use better quality low resistance copper conductors to reduce copper losses.
8. Maintain operating voltage, form factor and frequency at the rated values (power quality) so that losses are minimized.
9. Use better quality insulation materials to improve overload capacity.

2 b)   State and explain various reasons of technical losses in transmission and
distribution systems.
Ans:
Losses due to improper or lower attention towards technical aspects are technical
losses. In each case below the losses such as copper loss, iron loss, dielectric loss
and losses due to harmonic content are increased.
Different **technical losses** in transmission & distribution system-
1) A loss due to insufficient investment on transmission & distribution system.
2) Losses due to random growth of sub transmission &distribution system:
planned growth/expansion maintains the losses to optimum values as the
system conductors and other components are judiciously selected.
3) Losses due to large scale rural electrification through long 11KV & LT lines
unbalanced loading.
4) Losses due to many stages of transformation. (Large no. of transformers).
5) Losses due to improper load management such as unbalanced loading,
excessive overloads for large time periods.
6) Losses due to unsatisfactory reactive power compensation.
7) Losses due to poor quality of equipment used.

1 mark
each any 4
points = 4
marks

2 c)   Define the terms:
   i)   Electricity duty,
   ii)   Connected load,
   iii)   Electricity tax,
   iv)   Tariff structure.
Ans:
   i)   Electricity duty: An amount levied by government (state) depending on
          the energy units consumed (duty charge per unit consumed) or as
          percentage. This goes into the government account.

   ii)   Connected load: It is the sum of the power ratings (W or kW or MW) of
          all devices and machines existing (installed) in the premises of
          consumer. It is used to decide the fixed charges to be levied.

   iii)   Electricity tax: An amount levied by the state govt. normally as a
          percentage of the total electricity bill which includes all amounts that go
          to the electricity supply agency.

   iv)   Tariff structure: It is the methodology by which a consumer is billed for
          electricity which may include the components such as fixed charges,
          MD charges, pf incentives/penalty, load factor incentives/penalty,
          energy charges, TOD consumption charges etc.

1 mark
each = 4
marks

2 d)   Explain the procedure for assessing existing lighting system in a facility.
Ans:
Step I: prepare Inventories lighting system elements roughly as given below.

Device rating, population and use profile					
Sr no	Plant location	Lighting device and ballast type	Rating in watts: lamp and ballast	Population numbers	Operation hours per day

1 mark each step (variations allowed with the gist being parallel to given) = max 4 marks

Lighting transformer/rating and population profile:				
Sr no	Plant location	Lighting transformer rating	Installed numbers	Meters installed: V, I, kW, kWh.

Also note fuse ratings as placed.

Step II:
Use lux meter to measure and note the light levels at different places of work at day time and night time with the lamps put on during measurements.

Step III:
Using portable load analyser, measure and note the V, I, pf, and power consumed at different input points as lighting transformers, DBs etc.

Step IV:
Compare measured lux values with standard required and classify locations as under lit and over lit.

Step V:
Collect and analyze failure rates of lamps, ballasts, and actual life expectancies from past data.

[Step VI: (optional step for this question not expected)
Suggest improvement options based on above study as:
  • Maximize sunlight use by transparent roofs and other means.
  • Replacement of existing low efficacy fixtures with those with high ones without compromising the CRI, required lux etc.
  • Interior re-coloring.]
  • Modify layout for optimization.
  • Form/Modify control groups for lights.
  • Use sensor operated fixtures.
  • Install control gears or regulators.

2 e) State the working and applications of following energy conservation equipments.
   i)   Soft starter.
   ii) Power factor controller.
   Ans:
   i)   Soft starter:
        Soft starter applies the supply voltage to the motor in such a manner that the current never shoots up to create the additional drops of voltage and power in the lines and nor the unnecessary torque. It provides a step-less acceleration or deceleration. Leading to increase in motor life. The components used to achieve this are power electronic devices such as thyristors etc. by controlling their firing/phase such that only the amount of power needed is supplied to start the motors and increased gradually as the motor accelerates. This saves energy wasted during starting and also the mechanical stresses/shocks are avoided.   1 mark

        Application: used to start motors very smoothly without drawing excessive current, stop smoothly instead of sudden switching off the full supply.   1 mark

   ii) Power factor controllers:
        These are devices used to improve/control the power factor of electrical systems to the optimum value to maximize the savings in energy and thus conserve it.
             These switch in and out of the circuit the pf control components such as capacitors, synchronous condensers, phase advancers etc. as per the need for maximizing the savings in energy by reduction in the copper losses due to reduction in current drawn in lines. This also leads to lowering the voltage drop in lines giving near rated voltages to connected devices/machines/loads. Currents at lagging power factors are reduced to near unity power factors.   1 mark
             Large installations use automatic power factor controllers that sense and operate the switching system to maintain the power factor near unity.

        Applications: used in improving the power factors of inductively reactive loads such as large induction motors, induction furnaces etc. in case of leading loads the inductive reactors are switched as needed to compensate. The controlling aspect is important when the power factor varies continuously and has to be maintained at high levels.   1 mark

2 f) Draw energy flow diagram and state its three significances.
   Ans:
   Significances:
     1) Energy flow diagram also known as Sankey diagram is a specific type of flow diagram in which the width of the arrow is proportional to quantity of energy. Length of the arrows has no bearings with the quantity of energy.   1 mark each significance = 3 marks
     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 left of the diagram. The outputs (useful and

leakages/losses of energy are shown on the diagram.

Example energy flow diagram:
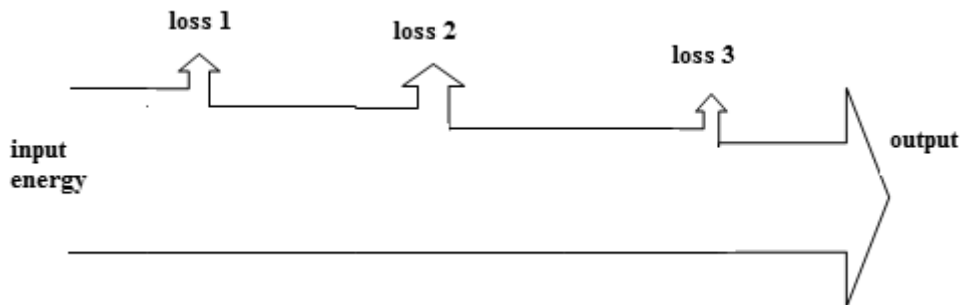
Sample diagram = 1 mark. Alternative diagram allowed for other processes.

| 3 | Attempt any four | 16 |

3 a) Explain energy conservation technique in induction motor by minimizing the idle and redundant running of motor.

Ans:

Points to be covered:

Minimizing idle and redundant running of motors: idle /redundant running leads mainly to following:

1) Loss of energy as the no load power drawn is approximately about 12 % to 16 % of rated power output in most of motors.
2) Un-necessary heat production at friction points as bearings leading to wearing of bearing.
3) Motor being inductive load the pf of such running is low leading to unnecessary losses line losses.
4) Reduction in overall system energy efficiency over period of time.

2 marks

Hence avoiding long periods of such operation of motors is needed to maintain a higher energy efficiency of operation and conserve energy.

- This can be achieved by switching off the motors during such extended periods of operation.
- Operating the motors at low voltages just to keep them running near their normal speeds.
- Redundant running implies the equipment is working without any effect on the production of quantity or quality. Unless these are operating for safety consideration stoppage of these motors can lead to large saving.

2 marks

3 b) With help of neat labeled diagram explain working of Gas turbine co-generation system?

Ans:

Gas turbine cogeneration systems can produce all or a part of the energy requirement of the site. The energy released at released at height temperature in the exhaust stack be recovered for various heating cooling applications. The typical range of gas turbines varies from a fraction a MW to around 100 MW. Gas turbine cogeneration has probably experienced the most rapid development in the recent

2 marks

years due to the greater availability of natural gas, rapid progress in the technology, significant reduction in installation costs, & better environment performance. Gas turbine has a low short start up time and provides the flexibility of intermittent operation. Though it has a low heat to power conversion efficiency more heat can be recovered at higher temperatures. If the heat output is less than that required by the user it is possible to have supplementary natural gas firing by mixing additional fuel to the oxygen –rich exhaust gas to boost the thermal output more efficiently . Steam generated from the exhaust gas of the gas turbine is passed through a backpressure of extraction – condensing steam turbine to generate additional power. The exhaust or the extracted steam from the steam turbine provides the required thermal energy.
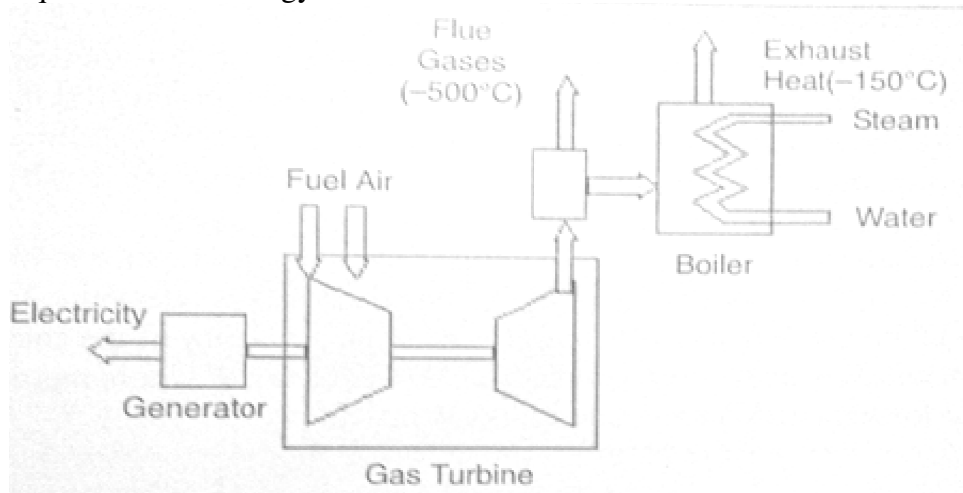
Diag. 2 marks

3 c)   A consumer has a maximum demand of 100 kW at 30% load factor. If tariff is Rs.90/kW of maximum demand plus 10 paise per kWh. Find overall cost per kWh.
Ans:
Assume given MD tariff is monthly.
Average load = MD x Load factor = 100 x 30/100 = 30 kW.
Monthly units consumed = average load x hours in month
                = 30 kW x (30 x 24)hrs = 21600 kWh.   1 mark

Energy charges per month = 21600 x 10/100 = Rs 2160/-
        MD charges per month = MD x MD tariff = 100 x 90 = Rs 9000/-.   1 mark
        Monthly bill = MD charges + energy charges
                = 9000 + 2160 = Rs 11160/-.   1 mark
Overall cost per unit per month = monthly bill/(monthly units consumed),

        = 11160/21600 = Rs 0.5166 = 51.66 paise.   1 mark

3 d)   What is ABC analysis? State its three advantages referred to energy audit projects.
Ans: (points to be covered)
-ABC Analysis,
 Normally 20% of a given population (items) represents 80% of a specific characteristic.
ABC analysis provides a mechanism for identifying different categories of activities/stocks/items that will require different management and controls.   1 mark

1) A class inventory: It contains 10 to 20 % of the items that account for 70% of total value.

2) B class inventory: This type of inventory contains 25 to 35 % items that account for 20% of total value.   2 marks

3) C class inventory: This inventory contains 40 to 50 % items that account for 10% of total value.

Advantages referred to energy audit projects:

1) The audit helps to identify items and the costs of energies involved there in.
2) Schedule the different processes to achieve overall maximum useful output using the minimum inputs without losses of quality.   Any three = 1 mark
3) Optimize the expenses on energy required.
4) Maximize the savings.
5) Reduce energy losses.

3 e) Write comparison between energy efficient motor and conventional induction motor (any four points).

Ans:

Sr	Points to compare on	Energy Efficient Motor	Conventional Motor
1	Construction	Thin & low loss laminations of core. Longer core. Large dia. Copper conductor , Low loss fan , aerodynamic designed rotor optimized design , quality control procedure in manufacturing	Laminations with higher flux densities. Cu/Al conductor with smaller dia. Al fan, standard quality controlled manufacturing process.
2	Efficiency	Higher upto 92 %	Lower upto 86%
3	Speed	(Slightly higher) nearer to synchronous, slip about 2.5 to 3% at full load.	Slip around 4 % at full load.
4	Starting torque	Good as required.	Sufficient

1 mark each point = 4 marks

4 A Attempt any three   12

4 A i) State four benefits of VFDs

Ans:

Following are the **benefits** of variable frequency drive:

1) Energy saving due to optimum use for applications.   1 mark each point
2) Smooth starting. Can start the motor under load smoothly.   any four =
3) Smooth speed control, Can increase (to 300%) or decrease (to 11%) of the rated speed. Hence higher speed range.   4 marks
4) Better process control, (with Micro controller and IGBT (Insulated Gate Bi-polar Transistor).
5) Cost saving.
6) Less maintenance cost due to optimum working.

7) Large life for bearing & motors.
8) Improved output power quality.

4 A   ii) Explain energy conservation techniques in transmission and distribution systems by
i) reducing I^2R losses.
ii) balancing phase currents
Ans:
i) reducing I^2R losses.

1. Opting for low resistance All Aluminum Alloy conductors (AAAC) in place of conventional Aluminum cored steel Reinforced (ACSR) lines.
2. Increasing the system voltage leads to reduction in the line current transmitted that leads to lower I^2R losses.
3. Using relevantly suitable means to reduce the line currents to lowest possible values by maintaining the power factor near unity (reactive power control, power factor improvement)
3. Use of voltage controllers to maintain the voltage level at rated levels (not allowing the voltage to fall that leads to higher line currents)
4. Maintaining proper distance (as low as economically possible) between consumer and distribution transformer.

2 marks

ii) Balancing of phase currents:

1. Proper (healthy balanced) three phase loads always draw equal currents in all lines but single phase loads in the 3 phase 4 wire system or loads connected between two phase lines lead to unequal currents in the lines. This leads to circulating currents due to which losses increase. As a result of unequal loads on individual lines, sequence components cause overheating of transformers, cables, conductors, motors. Thus increasing losses and resulting in motor malfunctioning under unbalanced voltage conditions. Due to unequal loading on the single phase lines of a 3 phase, 4 wire supply system the voltage drops in lines are different that create unequal (non-rated) phase and line voltages at the load leading to unhealthy effects on the loads. Large ovens/furnaces of the single phase and two phase types are such loads. Hence it becomes necessary to equate/balance the three phase/line currents at the supply terminals. For furnaces the Scott connection transformers are employed to derive the two phase supply from the three phases.
Unequal loading is also created due to unequal lengths of feeders of the three phases.
Hence it is necessary to obtain current balance to the maximum.
Benefits of phase current balancing:
1) Reduces feeder losses.
2) Balancing between phases tries to make uniform phase loading.
3) Reduces reactive power losses.
4) Improves voltage quality on feeders.

2 marks

The balancing of the loads has to be judiciously such that the feeders are properly loaded all along the lengths, though it is impossible to achieve an ideal balance condition at every point along the feeder.

4 A iii)State the incentives and penalty related with p.f tariff.
Ans:
Power factor incentive: It is given to consumers who have maximum demand based tariff and provided with meters to measure their power factor.
Whenever the average power factor is more than 0.95, an incentive shall be given at the rate of the following percentages of the amount of the monthly bill including energy charges, reliability charges, FAC, and Fixed/Demand Charges, but excluding Taxes and Duties.

Sr no	PF range	PF level	Incentive %
1	0.951 to 0.954	0.95	0
2	0.955 to 0.964	0.96	1
3	0.965 to 0.974	0.97	2
4	0.975 to 0.984	0.98	3
5	0.985 to 0.994	0.99	5
6	0.995 to 1.00	1.00	7

3 marks

Power factor penalty:
When the power factor falls below 0.9the consumer is penalized at the rate of 1% of the monthly bill for every fall of 0.01 of the power factor below 0.9.

1 mark

4 A iv)Explain the importance of amorphous core transformers from energy conservation point of view.
Ans:
Major energy losses in distribution transformers are the iron losses (hystserisis + eddy current) that occur continuously in the core while maintaining the operating flux throughout the day. These core losses in the conventional transformer whose core is made of silicon alloyed grain oriented iron laminations occur constantly during the time when the transformer is working for all loads: no load included.Amorphous cores are made of metallic glass (iron alloy) alloy that have these losses lower by about 70 %.

- Due to lower iron losses the loss at all loads is reduced resulting in significant improvement in the efficiency which may increase upto 98.5 % even at low loads.
- This material has high electrical resistivity. This is 2-3 times higher than that of silicon steel. This is partially responsible for low core (eddy current) losses.
- Amorphous steel has lower hysteresis losses. So, this means that less energy wasted in magnetizing & demagnetizing during each cycle of supply current.
- The all day efficiency of the transformers is increased that results in huge energy savings.
- As losses get reduced cooling problems are reduced and heat related problems are reduced.

Each point 1 Mark any four points = 4 marks

4 B   Attempt any one: 6 marks

 4 B   a) What are the types of tariff? Explain each.
         Ans: Less than 5
         Types of tariff =   1 mark
          1) Simple tariff   2) Flat rate tariff   3) Block rate tariff   Any five or
          4) Two part tariff   5) Three part tariff   6) Maximum demand tariff   more
          7) Power factor tariff   8) Time of day tariff.(TOD tariff)   2 marks

         1) Simple tariff :
         When there is fixed rate per unit energy consumed, it is called as Simple tariff or
         uniform rate tariff. In this type , the price charged per unit is constant. The
         consumption of electrical energy at the consumer's terminals is Recorded by   Explained
         means of energy metre.   any four 1
                                                                            mark each=
          2) Flat rate tariff: 4 marks
         When different types of consumers are charged at different uniform per unit rates, it
         is called as flat rate tariff. In this type of tariff, the consumers are grouped into
         different classes & each Class of consumers is charged at a different uniform rate.

          3) Block rate tariff:
          When given block of energy is charged at specified rate & the next blocks of
         energy are charged at progressively reduced rates, it is called as a block rate tariff.
         In block rate tariff, the energy consumption is divided into blocks & price per unit
         is fixed in each block. The price per unit in 1st block is highest & is progressively
         reduced for the Succeeding blocks of energy.

         4) Two part tariff:
         When the rate of electrical energy is charged on the consumer power demand & the
         unit consumed, it is called as two part tariff.   In two port tariff, the charge is split
         into two components i.e. Fixed charges & running Charges.
         The fixed charges depend upon the maximum demand of the consumers while the
         running Charge depends upon the number of units consumed by the consumers.
                       Total charges = Rs. (b*kw +c*Kwh)
         Where, b= charge per kW of maximum demand.
                C= charge per Kwh of energy demand.

         5) Maximum demand tariff:
          It is similar to two port tariff. The maximum demand is actually measured by
         installing maximum demand in meter at premises of consumer.

         6) Power factor tariff:
          The tariff in which power factor of the consumers load is taken into consideration
         is Known as power factor tariff. A low power factor increases the rating of station
         equipment & line losses. Therefore consumers having low power factor are billed
         higher.

         7) Three part tariff =

The   total charges are split into 3 parts:
1. Fixed charges.   2. Semi-fixed charges.   3. Running charge.
It is known as three port tariff.
 Total charges = Rs.(a + b*Kw + c*Kwh)
          a= Fixed charge. It includes interest & depreciation & labor cost.
          b= charge per kW of maximum demand.
         C= charge per Kwh of energy demand.

8) Time of day (TOD)tariff =
Many electrical utilities like to have flat demand curve to achieve high plant
efficiency. They encourage users to draw more power during off peak hours. They
provide an incentive to shift consumption from peak to off peak periods. Energy
metre will record peak & non-peak consumption separately by timer control. TOD
tariff gives opportunity for the user to reduce their billing. The off peak hours tariff
charges are quite low in comparison to peak hour's tariff. TOD tariff structure is
implemented for industrial consumers of MSEB since year 2000, because major
load on utility is industries.

4 B b) State need for energy conservation in electrical motors. Explain the effect of
      following parameter on three phase induction motor.
         i)   Harmonic distortion
         ii)   Voltage unbalance.
    Ans:
    Need for energy conservation in electric motors:
        1) Electric motors are a major part of the industrial arena (about 60% to 70%)
           and consume a huge amount of energy.
        2) Cost of electricity is increasing.
        3) For maximum savings motors must work at higher efficiencies.   2 marks
        4) Production costs cannot be reduced till the operating costs of machines used
           therein are reduced without sacrificing the quality.   (other
        5) Most of the electricity produced and utilized to drive the electrical motors   logical
           comes from the burning of precious fuels or using natural resources as coal, oil   needs may
           etc.   be
        6) Inefficient motors need large powers of which a major portion is lost.   considered)

 i) **Effect of harmonic distortion:**
     Due to distortion of the main frequency waveform by harmonics produced due
     to solid state devices, electromagnetic devices, arcing devices the high   2 marks
     frequency harmonics lead to increased copper losses and iron losses that results
     in overheating of motors (due to the harmonic voltages and resulting currents
     thereon). This leads to motor failures, lower life and improper torque speed
     characteristics.

 ii) **Effect of voltage unbalance:**
     For three phase motors this leads to unequal currents in the three phase
     windings that result in unbalance in the fields produced due to which negative   2 marks
     phase sequence currents are produced that cause oppositely rotating magnetic
     field to the normal one, leading to over heating in rotor.

5		Attempt any four	16

5 a)   State advantages of soft starter with reference to DOL starter.
Ans:
Advantages of soft starter with reference to DOL 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 any eight points = 4 marks (some may cover these points in paragraph forms)

5 b)   State and explain various factors governing the selection of 3 phase induction motor.
Ans:
Factors governing the selection of 3 phase induction motor:

1) Load torque required at normal speed matches with available torque of motor.
2) Break down torque or pull out torque or maximum torque must match with the maximum torque requirement by load.
3) Starting torque of motor must be more than that needed by load.
4) 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.
5) The torque speed characteristics available from the motor must match the requirements of the load.
6) The environment/atmosphere in which the motor is to be installed govern the motor operating characteristics required. Eg. Corrosive atmospheres, dusty atmospheres, high temperature spaces need properly chosen motors for drives.
7) Cost of the motor plays an important role if a range is available.
8) Easily procurable, quick and easily serviceable motors are normally preferred. Standard motors are normally preferred.
9) Normally while selecting motors its performance is verified from the test certificate.
10) 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.
11) If selecting an energy efficient motor the cost benefit analysis over the long run must be worked out.

1 mark each point any four points = 4 marks

5 c)   Compare conventional core transformer with amorphous core transformer on basis of i) initial cost of installation, ii) construction used, iii) material required and iv) losses.

Ans:

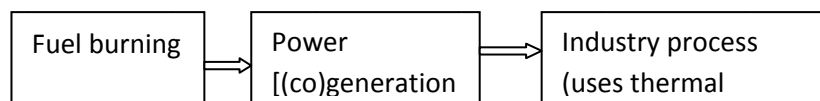| Sr. No.	Particulars	Conventional transformer	Amorphous core transformer
1	Initial cost of installation	Lower	Higher
2	Construction	Non-modular	Modular
3	Material required	i) Core manufactured with CRGO steel laminations. ii) Less quality copper in the winding.	i) Core manufactured with higher quality , low hysteresis/eddy current loss amorphous metal thin ribbon strip. ii) High quality low resistance copper conductors used in the winding.
4	Losses	High iron losses & copper losses	Lower iron and copper losses

5 d)   Give classification of cogeneration system based on sequence of energy generation.

Ans:

Points expected to be covered:

1) Topping cycle: the energy from fuel burnt is used to first produce power and then the thermal energy which is a by-product of the cycle and is used to supply process heat or other thermal requirements. Normally suitable where the processes of the industry need low heat (temperatures).   1 mark
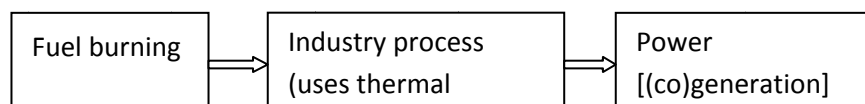
1 mark

```
┌──────────────┐     ┌──────────────┐     ┌──────────────────┐
│ Fuel burning │ ──> │ Power        │ ──> │ Industry process │
│              │     │ [(co)generation│     │ (uses thermal    │
└──────────────┘     └──────────────┘     └──────────────────┘
```

2) Bottoming cycle: the energy from fuel burnt is used at the high temperature thermal energy required for the process of the industry and then the heat rejected is recovered and used to generate power.   1 mark

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┌──────────────┐     ┌──────────────────┐     ┌──────────────────┐
│ Fuel burning │ ──> │ Industry process │ ──> │ Power            │
│              │     │ (uses thermal    │     │ [(co)generation] │
└──────────────┘     └──────────────────┘     └──────────────────┘
```
1 mark

5 e)   Draw block diagram of microprocessor based centralized control equipment of energy conservation and explain it.
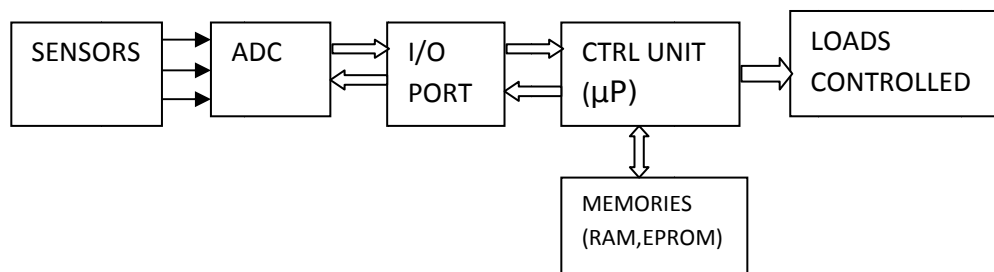
Ans:

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┌─────────┐    ┌─────┐    ┌────────┐    ┌──────────────┐    ┌────────────┐
│ SENSORS │ ─> │ ADC │ => │ I/O    │ => │ CTRL UNIT    │ ─> │ LOADS      │
│         │ ─> │     │ <= │ PORT   │ <= │ (μP)         │    │ CONTROLLED │
│         │ ─> │     │    │        │    │              │    │            │
└─────────┘    └─────┘    └────────┘    └──────┬───────┘    └────────────┘
                                               ⇕
                                        ┌──────────────┐
                                        │ MEMORIES     │
                                        │ (RAM,EPROM)  │
                                        └──────────────┘
```
Diagram 2 marks

The sensors (from different loads spaces) feed the relevant value to the ADC (analog to digital convertor) which is linked to the I/O port interfacing with the microprocessor unit which processes uses its memories (RAM, EPROM etc) to decide the loads to be controlled/corrected/switched accordingly to affect optimum savings.

2 marks

5 f)   State any four advantages of energy audit.
Ans:
Advantages of energy audit:
The energy audit helps us to identify energy losses that can be minimized by various means to achieve the following:

- Reduced expenditure on energy; e.g., by reducing consumption or changing tariff or fuel type.
- Reduced maintenance cost; e.g., following improved utilisation of plant and optimization in operation.
- Saving in other costs; e.g., water charges, where demand is reduced.
- Reduced capital expenditure; e.g., where increased efficiency avoids the need for additional plant or supply capacity or makes possible accurate sizing of any replacement plant.
- More productive use of labour where measures release staff for other duties; e.g., automated control systems.
- Increased productivity where working conditions are improved; e.g., improved temperature levels, airflow, etc
- Hedging against forecast increases in energy and water costs with the introduction of the carbon emissions trading scheme.

1 mark each any four = 4 marks

OR

1. Energy audits will evaluate the facility "as a whole", their goal is not to evaluate single measures but to consider a wide range of available alternatives (Electrical, Mechanical, Envelope and Water).
2. The audit identifies opportunities and provides financial analysis. This will enable prioritization based on financial benefit and return on investment.
3. Suggest technical information regarding the proposed energy conservation measures.
4. Provide emissions analysis to understand the benefits of decisions from an environmental standpoint.
5. Understand where energy is used and which areas are worth focusing on the most (energy hogs).
   Provide benchmark information to understand the energy use performance compared to others in similar area.

6   Attempt any four   16

6 a) State commercial losses in transmission and distribution system. Also state the remedies.
      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 each any four points = 2 marks

These can be reduced by: Installing summation meters for a group of customers to detect pilferage, fixing responsibility (on personnel) of the amount power drawn and amount of 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

6 b) What is power factor tariff? Explain how it help in energy conservation?
      Ans:

Forcing electricity consumers to maintain higher power factors leads to better performance of the electric power system in terms of power availability, system efficiency etc. This is achieved by the power factor related tariff offered to consumers making them to maintain higher power factor. The power factor related tariff will bill consumers on the basis of their kVA MD and (kWh & kVARh). By maintaining a higher power factor the consumers will be drawing lower currents for specified real power loads. Thus the line losses are low leading to increased system efficiency. Thus lower losses means lesser energy drawn and conservation of energy.

2 marks

2 marks

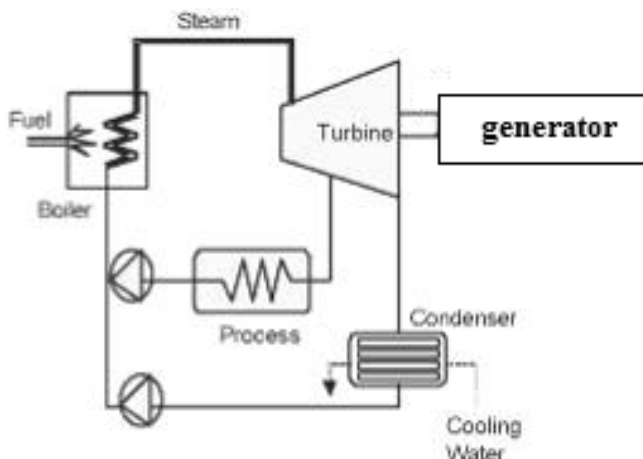6 c) Draw layout of steam turbine cogeneration system and label it.
      Ans:
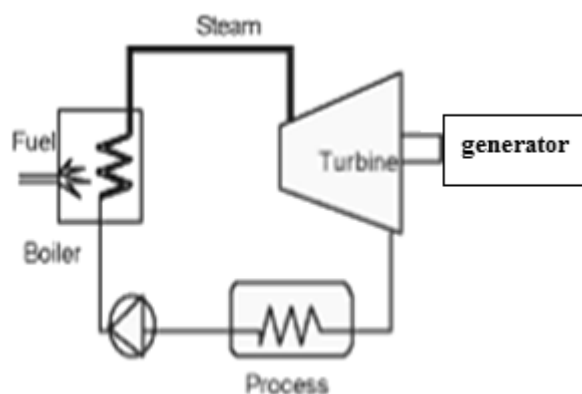
Back pressure steam turbine co-generation system.

Any one diagram or equivalent fully labeled 4 marks, partially labeled 3 marks, unlabeled 2 marks or 1 mark: discretion.

OR

Extraction condensation turbine co-generation

6 d) Explain the need of reactive power compensation in transmission and distribution system from energy conservation point of view.
Ans:
   The reactive power drawn through lines due to heavy reactive loads or conditions leads to increase in the kVA [as kVA = $\sqrt{(kW^2+kVAR^2)}$]. Higher kVA means higher current in lines. This current leads to higher line heating losses (I^2R) and hence drop in line efficiency and heavy line voltage drops. If this reactive power is compensated near the load ends such that the kVAR in line reduces leading to drop in kVA demand the current gets reduced thus decreasing the line losses and lowering the line voltage drops. The compensation also helps to supply higher loads as per the system capacity. There are reactive power compensating devices as capacitor banks and static VAR compensators that are used to carry out the compensation. Both lagging and leading reactive powers are compensated.
   Thus the energy is saved / conserved.

2 marks

2 marks

6 e) Write four objectives of tariff.
Ans:
Following are the objectives of tariff-
   1) Fair distribution of cost on consumers.
   2) Cost of investment (capital cost) in generation, transmission & distribution equipment must be judiciously recovered.
   3) Cost of operation, supplies, maintenance & losses must be recovered.
   4) Cost of metering, billing, collection & miscellaneous services must be recovered.
   5) Encourage consumers for saving energy. (eg. It should provide incentive for using power during the off peak hours).
   6) Penalise consumers for low power factor.
   7) Reap suitable profit on the capital investment.

1 mark
each point
maximum
4 marks