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 a) Write meaning of each of the following abbreviations: NPC, MEDA, BEE,MNRE.

1 A a) Ans:

1) NPC: National Productivity Council;
It is a national level tri-partite, non-profit autonomous organisation consisting of members from government as well as other technical & non-technical organisations. It provides services in the areas of training, consultancy & research in the field of energy and productivity. 1 mark

2) MEDA: Maharashtra Energy Development Agency;
State level organisation in Maharashtra constituted by the government of Maharashtra that works for the promotion of energy efficiency in all sectors. 1 mark

3) BEE: Bureau of Energy Efficiency;
A national level organisation constituted by the government of India to promote, disseminate energy efficient measures in all sectors including industrial and all areas where energy is being used. It achieves this by providing the proper platform of training and evaluation of energy efficiency measures feasible for implementation to achieve major savings in energy consumption without affecting the quality of the output. 1 mark

4) MNRE: Ministry of New and Renewable Energy;
Promotes new energy conservation techniques in industries etc. by giving incentives, helping in design of new techniques in energy efficiency measures, transferring new energy efficient cost effective technologies etc. 1 mark

1 A b) State recommended illumination level for each of the following:
Non-working area in a office,workshop, theater, godown.

1 A b) Ans: 1 each = 4 marks (other close figures may be considered)

1) Non-working area in a office: 30-50-100 lux.
2) Workshop: 200-300-500 lux.
3) Theater: 50-75-100 lux
4) Godown: 100-150-200 lux

1 A c) Explain how Variable Frequency Drive (VFD) can helps to conserve electrical energy.

1 A c) The variable frequency drive helps to conserve electrical energy as follows: 1 mark each any four = 4 marks.

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 (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 A d) Explain why frequent rewinding of induction motors reduces its efficiency.

1 A d) Ans:

Frequent rewinding may lead to the following: 1 mark each = 4 marks.

1) Increase in eddy current losses as heating the core for stripping old coils leads to fall in the lamination insulation resistance.
2) A change in the air gap or fitting of the rotor in stator gap can lead to increase in the reluctance or uneven reluctance as compared to the original parameters. Thus more magnetizing current is needed.
3) If the rewound motor has a smaller conductor cross section it leads to increased copper losses.
4) Improperly sized/shaped fans used after rewinding can lead to accumulation of heat in the motor, change in the operating characteristics, that lead to increase in the mechanical losses & hence decrease in effficency.

1 B Attempt any one 6 marks

1 B a) Write any six techniques that are to be adapted while designing energy efficient motors as compared to conventional induction motors.

1 B a) Ans:

1) Reduction in iron losses by using low loss silicon steel core material laminated to thinner dimension.
2) Using bigger length dimension (longer cores) to increase the area of magnetic flux due to which the flux density is lowered to reduce the eddy currents & hysteresis losses.
3) Lowering the air gap that leads to reduction of the reluctance of the magnetic circuit & hence lower magnetizing current to produce the same flux density.
4) Using low resistance copper bars in rotors instead of high resistance aluminum bars leading to reduction in the copper losses in rotor.
5) Use very smooth surface finishes of stator/rotor (air gap) leading to low windage losses
6) Use high quality bearings to reduce the frictional losses.
7) Use smaller diameter fans to reduce fan load (as above measures lead to lower heat production in motors & hence reduced cooling requirements).

1 mark each any six = 6 marks

1 B b) An energy conservation project of Rs. 5 lakhs saves 20 units of energy daily. If rate of electricity is Rs. 7 per unit, calculate Pay Back Period. Comment on this Pay Back Period whether investment should be done or not. Also write risk involved in this investment. Assume no. of working days is 250.

1 B b) Ans:

Assume that the given no. of days are the working days per year,

Pay Back Period in years $= \frac{\text{Capital investment}}{\text{Net annual savings (Rs)}} \text{ cost of the project/equipment (Rs)}$ — 1 mark

Net annual savings per year = units saved per annually x (tariff rate per unit)
= 250 x 20 x 7 = Rs.35000/- — 1 mark

Pay Back Period in years = (5,00,000)/(35000)
= 14.2857
= 14 years, 3 months, 13 days. — 1 mark

As the rate of energy charges vary progressively the payback period will change. Increased rates will lead to lowering of the period while decrease in rates will lead to increase in this period. — 1 mark

This period seems to be too much more as the life & cost of maintenance of the energy conservation project seems to have been over looked or has not been given. Hence investment can only be done if the above cost is low & there are no chances of the energy rates coming down. If these are not clear then this investment is not advisable. — 1 mark

The risk involved is already spelt above: life & cost of energy conservation equipment; 14 years is too long a period. If the equipment fails or incurs heavy maintenance expenses and the costs increase then this project will fail. — 1 mark

2 Attempt any four — 16

2 a) Explain how energy conservation can be obtained by replacing light sources (lamps) only.

2 a) Ans:

While replacing the lamps by higher energy efficient ones we must ensure that the required color rendering (CRI) is maintained else it has an adverse effect on the quality & rate of the work output. Also the cost involved must also be considered. — 1 mark

Replacing Lamps as follows: — ½ mark each = 3 marks

i) Replacing incandescent lamps (14 lumens/W) by Compact Fluorescent Lamps (CFL's) (70 to 90 lumens/W)
ii) Replacing conventional fluorescent lamp (50 lumens/W) by energy efficient fluorescent lamp (70 to 90 lumens/W)
iii) Replacement of Mercury/Sodium Vapour Lamp (around 50 to 75 lumens/W) by Halides Lamps.
iv) Replacing HPMV Lamps (50 lumens/W) by High pressure sodium Vapour Lamp(HPSV) (150 lumens/W).
v) Replacing filament lamps (10 to 15 W) on panels by LEDs (< 1 W).
vi) Using LED lights in place of all other lamps above as feasible (in terms of cost)

2 b) Explain how energy conservation can be obtained by periodic survey of lights.

2 b) Ans:

Periodic survey of lights:

Illumination level reduces due to accumulation of dirt on lamps and luminaries. By carrying periodic survey & deciding/carrying the maintenance i.e. cleaning, dusting of lamps and luminaries will improve the light output / luminance. 2 marks

As part of maintenance programme, periodic surveys of installation, lightning system with respect lamp positioning and illumination levels, proper operation of control gears should be conducted to take advantage of energy conservation opportunities as user requirements changes. 2 marks

2 c) A good quality core material reduces core losses in IK and transformers. Explain.

2 c) Ans:

A good quality core material as high grade CRGO silicon steel when thinly laminated lead to reduction of around 40 to 50 % in the iron losses (eddy current & hysteresis losses). This leads to increase in the efficiency by about 2 to 4 percent in transformers and 1 to 2 percent in induction motors. 2 marks

Use of amorphous cores for transformers has reduced iron losses 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. 2 marks
- 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.

2 d) With reference to Trans. And Distr. systems explain why reactive power should be compensated for conserving electric energy.

2 d) Ans:

Compensating reactive power flow:

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. 2 marks

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. 2 marks

2 e) Write any six energy conservation techniques that are to be considered while designing lighting for an educational institute for energy conservation.

2 e) Ans: Upto 2 pts = 1mark,

1) Use natural light in a diffused manner where ever possible such as for drawing halls, workshops etc.
2) Use energy saving fluorescent lamps/LED lamps without disturbing the CRI.
3) Use the recommended optimal level of illumination levels at different places.
4) Sectionalize/group the load using proper switches by functional sections so that they can be switched on or off as per the requirements of the particular loads.
5) Use separate transformer for lighting if the institute campus is very large & comprises of many sister institutes located therein. This leads to a high reduction in voltage fluctuations due to other loads & hence constant rated voltage to the lamps increasing their life and maintaining their rated light.
6) Locate switches conveniently such that the people who are responsible are able to operate them.

3 to 4 points = 2 marks, 5 points = 3 marks, 6 points = 4 marks

(other valid options must be assessed accordingly)

3 Attempt any four 16

3 a) Explain how energy can be conserved in induction motor by improving power quality.

3 a) Ans:

Power quality is defined by the closeness of the following to specified values:

1) Voltage
2) Frequency
3) Closeness of the supply to sine waveform [form factor $= \pi/(2\sqrt{2})$], which also is a means for knowing the harmonic content of the supply. 1 mark

1) Voltage: Maintaining the voltage at the rated value for motors results in the properly expected torque speed characteristics available to drive the load. Lower voltage leads to excessive current drawn due to which the line losses increase, machine copper losses increase, line voltage drops increase. Even if voltage is above required value higher flux density results in motors that leads to higher iron losses. These lead to decrease in efficiency. Hence proper voltage has to be maintained. 1 mark

2) Frequency: It governs the speed related losses and iron losses. If its value is more than rated these losses increase as speed is directly proportional to the frequency the speed dependent friction & windage losses increase that will decrease the efficiency. Lower value of frequency leads to lower speed that affects the output power. Hence frequency has to be maintained at rated value. 1 mark

3) When the supply waveform is purely sinusoidal the harmonics are absent which means no iron & copper losses due to harmonic voltage/currents. Also the harmonics even if very small lead to production of unwanted harmonic torques in motors which need to be overcome & this requires energy which is wasteful. Hence the supply voltage must be as near as possible to sine wave in case of AC motors. 1 mark

3 b) Explain how energy can be conserved by operating two transformers in parallel.

3 b) Ans:

The transformers operate near their maximum efficiency at around 70 % to 100 % of their rated loads. For a huge load system drawing highly varying powers at different times supplying from single transformer will be uneconomical and inefficient at low loads. 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 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. When more power is needed the other transformer if of higher rating may be put in service while the first one may be switched off. If the load 2 marks

3 c) Explain when induction motors are run in star connection under 30% load condition, how energy is conserved?

3 c) Ans:

In star mode operation of induction motors energy is conserved as follows:

1) Lesser than 30% load means torque required by load is less than 30 %. 1 mark

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

3) 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. 1 mark

4) Due to reduction in phase voltage the current drawn in the lines also reduces leading to lower copper losses in motor and decreased line losses. 1 mark

3 d) Explain how amorphous transformers are efficient as compared to conventional transformers.

3 d) Ans:

The iron losses (hystserisis + eddy current) occur in the core of transformers where the rated operating flux is maintained 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 %. 2 marks

- Due to lower iron losses the total 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 very low core eddy currents & hence very low losses. 1 mark
- 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. 1 mark
- As losses get reduced cooling problems are reduced and heat related problems are reduced.

Hence the amorphous core transformers are more efficient as compared to conventional transformers.

3 e) Explain how balancing of phase currents conserve energy in transmission line.

3 e) Ans:

Balancing of phase currents:

- 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 in transformers/ neutral conductors due to which losses increase. Hence balancing of such feeder currents is needed to reduce the feeder copper losses. 1 mark
- As a result of unequal loads on individual lines, sequence components in them cause overheating of transformers, cables, conductors, motors. These increase 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. 1 mark
- For furnaces the Scott connection transformers are employed to derive the two phase supply from the three phases which transforms the two phase load equally over the three phases.
- Unequal loading is also created due to unequal lengths of feeders of the three phases. 1 mark

Hence it is necessary to obtain current balance to the maximum.

Balancing of phases tries to:

- Make uniform phase loading.
- Reduces reactive power losses.
- Improves voltage quality on feeders.
- The balancing of the loads has to be judiciously done 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. 1 mark

4 A) Attempt any three: 12

4 A) a) Write meaning of each of the following terms with reference to tariff: connected load, load factor, max. demand, average load.

4 A a) Ans:

1) **Connected load**: sum of the continuous ratings of all loads (kW) installed in the premises under consideration. 1 mark

2) **Load factor**: ratio of the average load (kW) (over a specified period of time) to the maximum load (kW) (in the same period of time). Thus it may be determined daily, monthly, yearly etc. or as needed. 1 mark

3) **Max. Demand**: it is the highest demand (in kVA) of the premises under consideration over a specified period of time. Used to decide the demand charges in tariff. 1 mark

4) **Average load**: it is the average (kW) of the loads drawing power over a specified period of time determined by any recognized scientific method. 1 mark
Daily average load = (units supplied in 24 hrs- kWh)/ (24 hrs).
Monthly average load =
(units supplied in one month- kWh)/ (24x days in month).

4 A b) State any four advantages of co-generation system.

4 A b) Ans:

Advantages of co-generation system- 1 mark each any four = 4 marks (other valid parallel points may be considered)

1) Co-generation can meet both power & heat needs.
2) A much more efficient use of primary energy can be achieved as compared to separate production of electricity & heat.
3) Many times it is implemented in a very cost effective manner.
4) Increases overall efficiency of the system.
5) Reduction in emission of pollutants due to reduced fuel consumption.
6) In this system heat generated is the by-product of electricity generating process.
7) Helps to maintain grid stability.
8) Due to decentralization of electricity it avoids transmission losses & makes system more flexible.

4 A c) Explain how TOD and peak-off tariff can helps for energy conservation.

4 A c) Ans:

Electric supply agencies always try to achieve high plant efficiency by operating near full load for as much time as possible. They encourage users to draw more power when the load on their plants is low for which they keep tariff rates graded such that, lower the demand on their plants/substations lower will be the tariff rate to encourage the consumers draw power then. 1 mark

TOD tariff gives opportunity for the user to reduce their billing. During off peak hours they provide an incentive to shift consumption from peak to off peak periods. The off peak hours tariff charges are quite low in comparison to peak hour's tariff. TOD tariff structure is implemented for industrial consumers as their 1 mark

load demands are very high.

As the supply agencies get loaded as much near to the rated load for longer times of the day their overall efficiency gets higher helping to conserve energy. 2 marks

4 A d) State any four objectives of tariff.

4 A d) Following are the objectives of tariff of a supply agency:

1) Recover capital investment made.
2) Cost of operation, supplies, maintenance & losses must be recovered.
3) The cost incurred must be judiciously distributed amongst the consumers.
4) Cost of metering, billing, collection & miscellaneous services must be recovered.
5) Encourage consumers for using power during the off peak hours so that plant efficiency & load factor are high.
6) Discourage users from drawing higher loads than contracted.
7) Should have a provision of penalty for low power factor.
8) Gain suitable profit on the capital investment.

Any four points 1mark each = 4 marks

4 B Attempt any one: 6 marks

4 B a) Explain how losses are increased in Trans and distr. System due to each of following. Low power factor, low transmission voltage, transmission line voltage imbalance.

4 B a) Ans:

1) Low power factor: for a certain real power load low pf leads to increase in the current in the different conducting sections. 2 marks
As 'I' = P/(V x pf).
This increased current leads to higher copper losses in the concerned system conductors. Hence losses increase with fall in power factor.

2) Low transmission voltage: Motoring devices supplied with lower voltage draw excess current to handle the load as 'I' = (o/p)/[η V pf]. This excess current leads to increased copper losses in the supply lines & machine windings that lead to decrease in efficiency. 2 marks

3) Transmission line voltage imbalance: due to this the currents in the different phases will be unequal that will lead to higher currents in the neutral and hence increased losses especially in the motor loads. A 5% imbalance causes 40 % increase in motor losses. Also the negative phase sequence currents will be active and create extra losses. 2 marks

4 B b) An industrial consumer having a maximum demand of 100 kW maintains a load factor of 65 %. The tariff rates are Rs. 900 per kVA of maximum demand per annum plus Rs. 2.85 per kWh of energy consumed. If average power factor is 0.8 lag, calculate the total energy consumed per annum and annual electricity bill.

4 B b) Ans:

Average load = (LF) x (MD in kW) = 0.65 x 100 = 65 kW. 1 mark

MD (kVA) = (MD in kW)/(avg. pf) = 100/0.8 = 125 kVA. 1 mark

Annual units consumed N = Average load x no. of hrs in a year 1 mark

= 65 x 365 x 24 = 569400 kWh. 1 mark

Annual bill = MD charges + Energy charges

= 125 x 900 + 569400 x 2.85 = Rs. 112500 + 1622790 1 mark

= Rs. 1735290/- 1 mark

5 Attempt any four: 16 marks

5 a) Explain how energy can be conserved by reducing commercial losses.

5 a) Ans:

Different **commercial losses**:

1) Losses due to unauthorized extension of loads.
2) Losses due to errors in meter reading & recording. 1 mark
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.

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. 1 ½ marks

These remedies lead to proper evaluation of the energy produced, distributed and utilized. They will lead to avoidance of improper /unwarranted use of available energy which in turn reduces the energy requirements by some scale in turn leading to saving in energy resources. 1 ½ marks

5 b) Explain how motion detectors can be used for energy conservation.

5 b) Ans:

Motion detectors when installed at proper places in rooms or at entrances detect moving entities (human beings) and switch on the lights/fans/air-conditioning units as required as long as there is someone in the room. 2 marks

As soon as the last person leaves the room these electric loads are switched off by the controller circuits thus saving energy / conserving energy. 1 mark

These use transducer sensors, counter circuits, intelligent load circuit controllers etc. 1 mark

5 c) With the help of conceptual diagram explain what co-generation is.

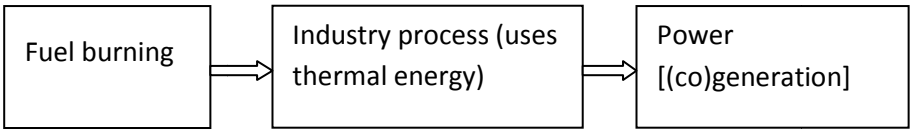
5 c) Ans:

Co-generation is the combined utilization of multiple forms of energy produced by some primary source in a useful manner to avoid wastage of energy produced in the primary stage of a certain industrial process or it is a system in which the multiple outputs of a single source of energy: such as (heat energy, mechanical (motional) energy & electrical energy are obtained to efficiently utilize the source input. 1 mark

This can be achieved in two main ways as given below:

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. Suitable where the processes of the industry need low heat (temperatures). 1 ½ marks

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 ½ marks



5 d) Explain how each of following conserves energy in lighting system voltage stabilizers, dimmers.

5 d) Ans:

Voltage stabilizers:

Wherever, installation of separate transformer for lighting is not economically attractive servo stabilizer can be installed for the lighting feeders. This will provide stabilized voltage for the lighting equipment. The performance of chokes, ballasts, will also improve due to the stabilized voltage. This system also provides the option to optimize the voltage level fed to the lighting feeder. In many plants, during the non-peaking hours, the voltage levels are on the higher side. During this period, voltage can be optimized, without any significant drop in the illumination level. High voltages lead to higher light output (un-necessary) consuming higher energy, hence stabilizers are used to control the voltage to such light sources 2 marks

Dimmers:

These are devices whose output voltage can be varied starting from a very low

value to rated. When supplying to lighting loads these provide the required voltage level for optimum illumination thus avoiding excessive brightness and saving in the energy inputted to the light sources. These dimmers are available in rheostatic forms, auto-transformers & electronic regulator circuits (thyristor dimmers). The most energy efficient ones are the thyristor type. 2 marks

5 e) Explain any four advantages of centralized control equipment for conserving energy.

5 e) Ans:

Advantages of centralized control equipment: Any four 1 mark each = 4 marks (other relevant answers to be assessed accordingly)

1) Intelligently switches on/off lighting loads as per the occupancy requirement.
2) When controlling air conditioning they effect a huge savings.
3) Maintains desired level of illumination or controls the intensity of light in the occupancies.
4) Time scheduling can be done for switching on / off the lights.
5) Timer based/ time of day based / prevailing illumination based lighting control possible for optimization of the lighting circuits.
6) In latest applications it saves energy utilized for lighting, fan & air-conditioning by sensing and switching according to requirement.

5 f) Explain how soft structures helps to conserves energy.

5 f) Ans:

Soft starter:

Soft starter delivers a controlled power to the motor to provide smooth, step less acceleration and deceleration. It consists of thyristors in the main circuit and the motor voltage is regulated with a printed circuit board. So as the voltage is low at the time of starting, current & torque developed will be also low. During starting period the soft starter provides low voltage to motor which enables to adjust the play between the gear wheels or stretching driving belts or chains etc. In other words it eliminates unnecessary jerks during the start. Gradually the voltage and the torque increase so that the machinery starts to accelerate. 1 mark

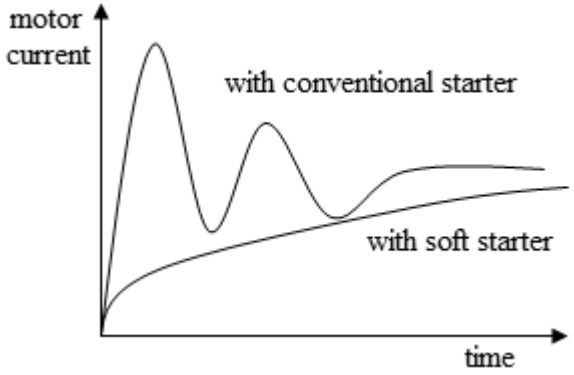


Figure 1 mark

The line voltage drops & losses at start are thus very low. It provides a reliable and economical solution to overcome problem related with starting. Due to low torque developed lower mechanical stresses are produced. Improved starting

power factor. Lowers maximum demand. Wear of bearings reduces hence low frictional losses. Provides soft stop function (useful in stopping pumps where water hammering in the pipe system occurs at direct stop). — 2 marks

6 Attempt any four: — 16

6 a) Write different steps of energy audit of an industry.

6 a) Ans:

1) Defining scope of audit.
2) Form audit team.
3) Estimate time frame and budget.
4) Collect information of different sections in all respects (no measurements).
5) Conduct site inspection and identify strategic measurement points.
6) Conduct measurements at strategic points.
7) Analyse data collected.
8) Identify energy management and conservation opportunities.
9) Schedule maintenance and other related activities.

Full coverage 4 marks

Partial proportionally lower marks

6 b) Prepare any eight questions related to energy audit of shopping mall.

6 b) Ans:

The main aim of the questionnaires it is to collect the basic data:

I) Availability of drawings of electrical, plumbing works?

II) No of personnel employed, Hours of working,

III) Equipment / components:

A) Type of supply:
   1. Specifications, arrangement of receiving it.
   OR

B) Supply Transformer-
   1. Type of transformer?
   2. Location?
   3. Output voltage?
   4. KVA ratting?
   5. Supply voltage?
   6. Present load nature and value?
   7. Remark?

C) Own substation?
   1. Location.
   2. Drawings of layout.

D) Power factor improvement
   1. Types of capacitors
   2. Ratings?
   3. Switching schedules.

½ mark each any eight = 4 marks, other valid points also to be considered

E) Air conditioning system-
1. Type?
2. Location of compressor?
3. Rating?
4. Piping?
5. Gas name if gas used?

F) Lighting (location wise or floor wise or section wise)
1. Type of lamps?
2. Type of work?
3. Lumen output?
4. Wattage of lamp?
5. Method of switching?
6. Operating load?
7. Operating hours?

G) DG set (Diesel Generator Set)-
1. Type of DG set?
2. Capacity?
3. No. of DG set?
4. Fuel used?
5. % loading?
6. Units generated annually?

H) Standby Generator-
1. Type of generator?
2. No. of generator?
3. Load capacity?
4. Rating?

I) Lifts used.
1. Capacities ?
2. Locations ?
3. Frequency of use?

J) Exterior lighting system plans & drawings ?

6 c) Classify cogeneration system based on sequence of energy generation. Explain working of each of them with diagram.

6 c) Ans:
Cogeneration systems are classified on the basis of sequence of energy generation as topping cycle & bottoming cycle. 1 mark

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

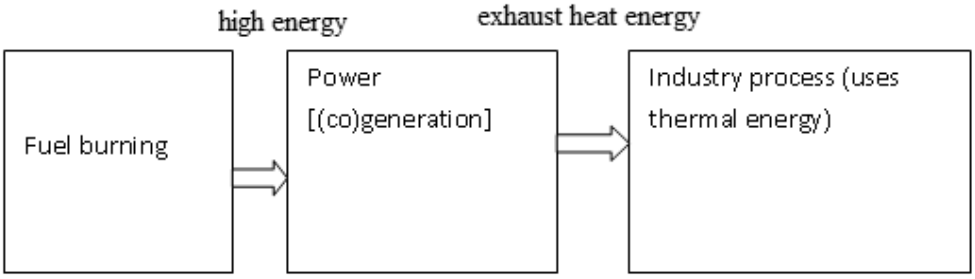


Figure ½ mark

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

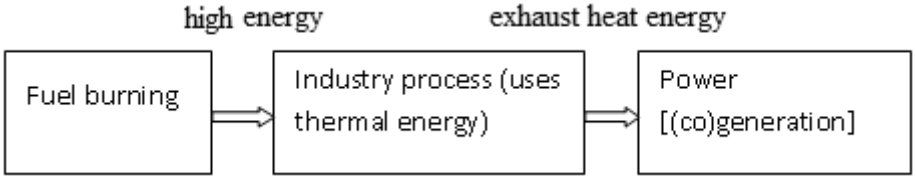


Figure ½ mark

6 d) State any four factors on which co-generation system is selected.

6 d) Ans:

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 mark each = 4 marks

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.

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

Other valid points may be considered

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.

6 e) Explain use of ABC analysis in energy audit project.

6 e) Ans: (points to be covered)

ABC analysis is used to identify components of a project (energy conservatio project in our case) that have major & minor influences on the cost. The major & minor influecial components are classified into items of lists A, B, & C. maintaining a tight control over these and using them judiciously in a scientifically determined manner leads to optimisation of the project cost. 1 mark

Of the total cost of the energy conservation project implementation:

List 'A' contains items that account for approximately 70% of total cost but these items (major energy inputs / outputs related) number around 7 to 10% (which are very important) of total numbers;

List 'B' contains items that account for approximately 20% to 25% of total cost but these items (medium importance energies related) number around 20 % (which are only important) of total numbers;

List 'C' contains items that account for approximately 5% to 10% of total cost but these items (very minor energies related) number around 50 to 70 % (which are not important) of total numbers. 2 marks

Advantages referred to energy audit projects:

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

Any three = 1 mark