Important suggestions 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 may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and communication skills)
4) While assessing figures, examiner may give credit for principle components indicated in a figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may 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.
6) In case some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q.1 A)	**Attempt any FIVE of the following :** **10 Marks**
a)	**Define Energy conservation.**
Ans:	**Energy conservation:** **(2 Marks)** Reduction in the amount of energy consumed in a process or system, or by an organization or society, through economy, elimination of waste, and rational use is referred as energy conservation. **OR** It is defined as reducing growth of energy consumption by avoiding unnecessary usages of energy by applying the energy conservation techniques. **OR** It's the process of reduction in the growth of electrical power utilization and to avoid unnecessary use of electrical power and to increase the efficiency of every machine and material by minimizing the losses.
b)	**List any two functions of MEDA.**
Ans:	**Functions of MEDA:** **(Any Two point expected : 1 Mark each, Total 2 Marks)** 1. To decide long term energy conservation policy's for Maharashtra state. 2. To coordinate with central government organization i.e NPC, MNRE etc for energy conservation policy's with state government. 3. To decide delivery mechanism for energy efficiency services.

	4. To promote/implement energy conservation techniques at state level. 5. To prepare public awareness regarding with energy conservation in our society. 6. To decide penalty, incentive, subsidy for energy conservation at state level.
c)	**List the energy conservation technique in induction motor.**
Ans:	**Following are the list of energy conservation techniques in electrical motors:** **(Any TWO point expected: 1 Mark each)** 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 finishing 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). 8) By minimizing idle & redundant running. 9) By matching motor rating as per required load. 10) By Phase balancing. 11) By improving power quality. 12) Operating motor in star mode at light load. 13) By rewinding in induction motor 14) By motor survey
d)	**Define the following terms : (i) Luminous intensity (ii) Luminous flux**
Ans:	**1) Luminous intensity:** **(1 Mark)** This is defined as the luminous flux emitted per unit solid angle of space in a specific direction. Its unit is the candela. **OR** The luminous flux per unit solid angle (per steradian), as measured in the given direction relative to a light source. Its unit is the candela. **ii) Luminous flux :-** **(1 Mark)** The luminous flux is the total energy radiated by the light source in all direction.

e)	**State the losses in secondary distribution system.**
Ans:	**The losses in secondary distribution system:** **(2 Marks)** **a) Technical losses: (Any 2 expected)** 1. Due to poor voltage 2. Due to unbalance load 3. Due poor quality of transformer & its components 4. Due to poor quality of conductor. 5. Copper lossess 6. Long distance between transformer &load **b) Non Technical losses: (Any 2 expected)** 1. Due to improper metering 2. Due to use of induction type of energy meter. 3. Lack of administration. 4. Energy theft 5. Unmetered supply
f)	**State the advantages of cogeneration.**
Ans	**Advantages of co-generation:** **(Any TWO point expected: 1 Mark each)** 1) Co-generation can meet both power & heat requirements. 2) Less cost than conventional generation. 3) Higher system efficiency due to energy wastage is highly reduced. 4) Reduction in emission of pollutions 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. 8) Overall cost of product reduces. 9) Transmission and distribution losses reduces due to cogeneration plant is located in same premises. 10) It can maintain grid stability

g) List the different types of tariff.

Ans: **Various types of Tariff:-** **(Any Two types expected: 1 Mark each)**

1) Flat-demand Tariff

2) Simple-demand Tariff or Uniform Tariff

3) Flat-rate Tariff

4) Step-rate Tariff

5) Block-rate Tariff

6) Two-part Tariff

7) Maximum demand Tariff

8) Three-part Tariff

9) Power factor Tariff :- a) KVA maximum demand Tariff

b) Sliding Scale Tariff or Average P.F. Tariff

c) KW and KVAR Tariff

10) TOD (Time of Day) Tariff
11) TOU (Time of Usage) Tariff

Q.2 Attempt any THREE of the following : 12 Marks

a) State the difference between energy conservation and energy audit. (any 4)

Ans: **(Any Four Point expected: 1 Mark each)**

S.No	**energy conservation**	**Energy audit.**
1	It is reducing the growth of energy consumption by avoiding unnecessary usage of energy	It is an inspection, survey & analysis of energy flows in building or system to reduce the amount of energy input to the system
2	Energy conservation techniques can be carried out by energy manager.	Energy audit procedure can be carried out by energy auditor.
3	Energy conservation procedure is carried out after energy auditing.	Energy audit procedure for the given plan is carried out initially.

4	Energy conservation procedure is costly, time consuming and depends on consumers application.	Energy audit is the procedure for better energy conservation.
5	Energy conservation devices are required for energy conservation techniques.	Various measuring instruments, with proper sensing elements are required for the energy audit.

b) Explain the energy conservation technique " By improving power quality of I.M."

Ans: The energy conservation technique Improving power quality of I.M : **(4 Mark)**

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

1) Voltage :
2) Frequency **(voltage & frequency should be within the tolerance limit without harmonics)**

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.

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.

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 and over heating 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.

OR

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.

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 I^2R loss in motor. Voltage unbalance produces negative sequence current which causes overheating.it reduces life of motor.

ii) Maintaining voltage & frequency value:

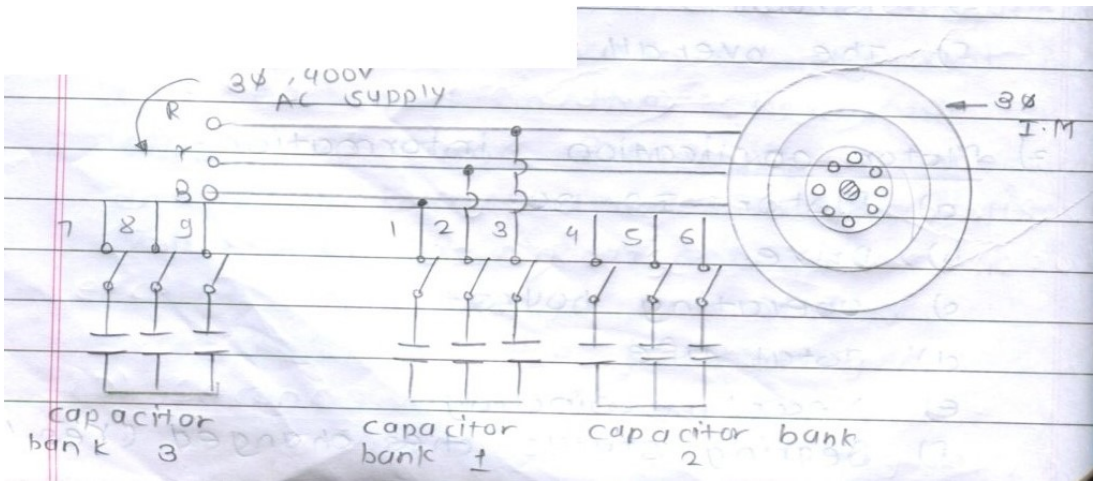
Maintaining the frequency and the required form factor minimizes the harmonics, and iron / mechanical losses as the speed is maintained at specified value. As speed of motor is directly proportional to frequency, speed will increase which will cause friction and windage losses and improper torque

iii) Harmonic distortion :

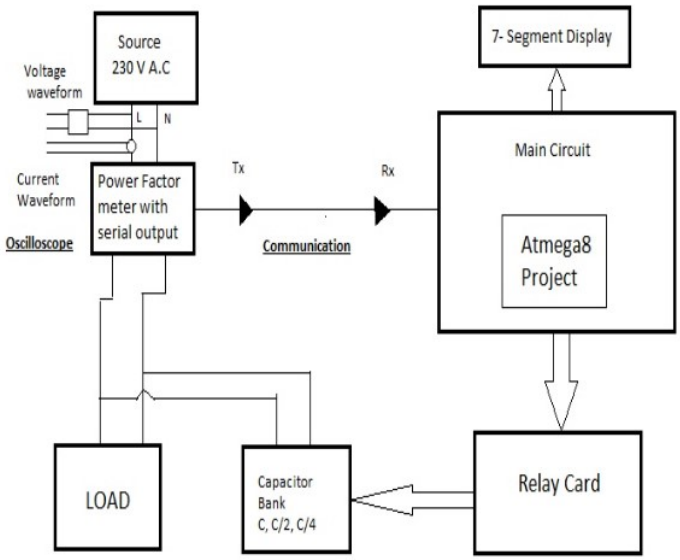
Increased use of the power electronics devices in the system leads to add the harmonics in a supply frequency. Undesirable effect of these higher frequencies related to the harmonic voltage distortion causes increase in iron and copper losses in motor. Overheating due to harmonics leads to motor failure, lower life and improper torque speed characteristics.

c) State the working principle and operation of automatic power factor controller used in transmission & distribution system.

Ans: Diagram of Automatic over factor controller: **(Figure: 2 Mark & Working : 2 Mark)**



or equivalent figure



OR Equivalent figure

Automatic Power factor control:

- The pf controller is used to maintain the pf at unity across the lines it is connected.
- Maintaining the pf at unity leads to reduction in the current through the lines as real power = apparent power x pf. The apparent power decides the MD for which the consumer is billed.
- For a certain motor the current in the lines will depend on its pf which is lagging. For higher pf near unity maintained at the motor terminals the line currents are minimized leading to lower MD and hence saving in MD charges.
- If PF is above reference value then microprocessor will not take any action, but when PF falls below reference value then it will send signal to relay and relay will connect respective capacitive bank across the load.

OR

1. Please check if required kVAr of capacitors are installed.
2. Check the type of capacitor installed is suitable for application or the capacitors are de rated.
3. Check if the capacitors are permanently 'ON'. The Capacitor are not switched off
4. when the load is not working, under such condition the average power factor is found to be lower side.
5. Check whether all the capacitors are operated in APFC depending upon the load

operation.

6. Check whether the APFC installed in the installation is working or not. Check the CT connection is taken from the main incomer side of transformer, after the fix compensation of transformer.
7. Check if the load demand in the system is increased.
8. Check if power transformer compensation is provided.

OR

- In automatic power factor controller the P.f. I.M is checked and to improve that power factor the required value of capacitance is calculated and only these capacitors among the capacitor banks are switched ON and P.F. of I.M will be increased.
- In APFC panel, the switching procedure of the capacitor bank is stepwise but in IPFC panel, the switching of capacitor is very smooth and better P.F. control is possible.

d) Write any four merits of cogeneration.

Ans: Merits of co-generation: **(Any FOUR point expected: 1 Mark each)**

1) Co-generation can meet both power & heat requirements.
2) Less costly than conventional generation.
3) Higher system efficiency due to energy wastage is highly reduced.
4) Reduction in emission of pollutions 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.
8) Overall cost of product reduces.
9) Transmission and distribution losses reduces due to cogeneration plant is located in same premises.
10) It can maintain grid stability.

Q. 3	Attempt any THREE of the following : 12 Marks
a)	**State the needs and benefits of star labelling.**
Ans:	**Needs of star labelling:** **(Any Point expected : 1 Mark each, 2 Marks)** ➢ Star labelling is meanly required to recognize quality of product ➢ Star labelling is also required to determine life and efficiency of the product. ➢ Star labels identifies percentage of energy conservation products. **Benefits of star labelling :** **(Any Point expected : 1 Mark each, 2 Marks)** 1. Due to the star labelling quality of the product is maintained. 2. It standard reduces energy cost. 3. The standard protects consumer rights. 4. Due to the standard green hose emission and air pollution will be reduces. 5. Market efficiency and compilation will be improve.
b)	**State the advantages of amorphous core transformer.**
Ans:	**Advantages of amorphous core in Transformer:** **(Any FOUR Advantages expected: 1 Mark each)** 1) Lowest hysteresis loss. 2) Low eddy current loss. 3) Low temperature rise 4) Up to 75% energy saving using amorphous metal than conventional metal. 5) Reduced carbon dioxide emission. 6) Reduction in fossil fuel consumption. 7) Reduced magnetizing current. 8) Better overload capacity. 9) High Reliability. 10) Excellent short circuit capacity. 11) Less maintenance cost. 12) It can be easily magnetized and demagnetized

c)	**Describe the following energy conservation techniques in lighting system : (i) replacing lamp source (ii) using light control gear**
Ans:	**Energy conservation techniques in lighting system :** **(i) Replacing lamp source** **(2 Mark)** 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. **Replacing Lamps as follows**: 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) **Energy conservation techniques in lighting system :** **(ii) Using light control gear** **(2 Mark)** 1. Flexibility can be obtained in lighting system by using following light control systems. It also saves power by switching off and by reducing luminance. 2. Grouping of light points: Grouping of lighting system, which can be controlled manually or by timer control. In this two or more no, of light points can be controlled by one switch. Such types of controllers are used in corridor lighting, go-downs, street lighting. 3. **Ballast:** It is the electrical or electronic chock which is commonly used in fluorescent tube or mercury vapour lamp. The main function of ballast is by applying the high voltage or high frequency across to the gas tube the light is emitted through the gas tube.

At the time of supply voltage variation the current flowing through the discharge tube is maintained constant, so that light intensity on working plane will be maintained.

4. **Ignitor :**

The ignitors are often called as starter or starting electrode. Generally ignitors are used in metal halide lamps or sodium vapour lamp. To increase the temperature surrounding the inner tube by current flowing initially after the temperature increases then full light will be emitted through these discharge tube.

5. **Illumination level:**

As per the IES the lux level for every working plane is decided so these factors also used for control the lumens level on working plane.

OR

1. Specific amount of current flow is required for lamp operation. Light controlled gears are devices which control the flow of current through light source and keep it in limit.

2. Light controlled gears can be also known as Ballast
3. Use electronic ballast instead of electrical choke.
4. Electronic ballast operates at high frequency. It has low losses so lamp efficiency increases.

d) State ABC analysis related to energy audit.

Ans: **ABC analysis related to energy audit.-** **(4 Marks)**

- ABC analysis provides a mechanism for identifying different categories of activities/stocks/items that will require different management and controls.
- "A class inventory" contains items that account for 70% of total value.
- "B class inventory" contains items that account for 20% of total value.
- "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.

ABC Analysis Helps in Energy Audit:

An energy audit is an inspection survey and an analysis of energy flows for energy conservation in a building. It may include a process or system to reduce the amount of

	energy input into the system without negatively affecting the output. In commercial and industrial real estate, The ABC analysis works in a manner as to get prime attention to the important items or the critical few and not have unnecessary attention to be spent on the not so important items. This prioritization of attention and focus is vital to keep the costs in check and under control in the supply chain system. To get the best results, it is important that the items having a lot of costs are given the due management attention. **OR** 1. It helps to identify atoms and cost involved 2. Reduce Energy losses. 3. Improves efficiency. 4. Maximize the saving 5. Optimize the expenses on energy required. 6. It helps to achieve maxium useful any three output.
Q.4	**Attempt any THREE of the following : 12 Marks**
a)	**Why energy conservation technique should be adopted in transformer even though its efficiency is mostly more than 90%.**
Ans:	**Reason for energy conservation techniques should be adopted in transformers even though its efficiency is 90% : (4 Marks)** ➢ Transformer performance depends on its efficiency. Transformers used in real-time applications suffer from load as well as no load losses. Loss of efficiency reduces transformer performance. Hence, customers should try different types of methods to improve the efficiency of the transformer. ➢ Since transformer is almost connected in circuit for 24hrs. Continuously so it is necessary to reduce the losses. ➢ By different techniques it is possible to improve the efficiency of the transformer more than 90% as there are no mechanical losses. ➢ In the Transmission and distribution system almost 40% losses of total TDL losses are occurring in transformers it very huge capacity (8000 MW to 9000 MW) , so we have to minimize it by energy conservation techniques.

b)	**State the various commercial losses in transmission & distribution system. Also, state EC technique adopted for optimizing distribution system.**
Ans:	**Following are the commercial losses in Transmission and Distribution :** **(Any TWO commercial losses expected: 1 Mark each)** 1) Make unauthorized extension of loads. (Direct Hooking) 2) Errors in meter reading & recording (faulty meter). 3) By passing the meter. (unmetered supply & unmetered bills) 4) Improper testing & calibration of meters. 5) Stopping the meters by remote control. 6) Changing the sequence of thermal wiring. 7) Changing the C.T. ratio. 8) Intentional burning of meters. 9) Billing issues 10) Lower collection efficiency. OR 1) Power theft (Direct hooking) 2) Unmetered supply 3) Meter in accuracies 4) Meter discrepancies 5) Small unmetered loads 6) Billing issues 7) Lower collection efficiency **EC (Energy conservation) technique adopted for optimizing distribution system:** **(2 Marks)** ➢ **These can be reduced by:** Installing submeters 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. ➢ 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 sources. ➢ Appoint vigilance squad for to avoid the energy theft. ➢ Make the necessary energy audit time to time. ➢ Apply high penalty for meter tampering cases. ➢ Faulty meter should be replaced immediately. ➢ Better coordination is essential for to avoid lack administration. ➢ Billing issues such as bill not received, lower collection efficiency and wrong bill received issues should be cleared. ➢ Defected or dissimilar meters should be replaced.
c)	**Discuss how power factor tariff results in energy conservation.**
Ans:	**Power Factor Tariff :** **(4 Marks)** In addition to basic tariff (Maximum Demand Tariff / KVA Maximum Demand Tariff / Load factor tariff) the tariff in which P.F. of industrial consumer is taken into consideration is known as Power-factor tariff. If the P.F. of consumer is less than P.F. declared by Supply Company (say below 0.9 lag) then penalty will be charged in energy bill. If the P.F. of consumer is more than P.F. declared by Supply Company (say above 0.95 lag.) then incentive will be given in energy bill. As usual consumer has to pay actual energy consumption charges. In the power factor tariff the datum power factor is fixed by supply company. If this power factor is improved by using APFC or IPFC by the consumers then incentive (reward) in the consumers energy bill is immediately provided. If the consumer Power factor is poor (less than datum power factor) then penalty is applied to the consumers. It means by maintain the power factor reactive power is controlled and it is one of the energy conservation techniques.

d) State difference between "walk through audit" and "detailed audit".

Ans: **(Any Four point expected: 1 Mark each)**

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

e) Define and explain the procedure to calculate the payback period. Also, state its significance.

Ans: **Definition Payback period:** **(1 Mark)**

It is the time required for an energy efficient method to cover its purchase, installation and running cost.

OR

Payback period is the time required to recover the funds invested in a project.

Procedure of Payback period = **(2 Mark)**

$$Payback\,period = \frac{first\ intial\ cost\ of\ energy\ conservatin\ device}{Annual\ saving\ of\ energy\ in\ amount}$$

- First initial cost of energy conservation device = Additional cost of purchasing the new energy efficient equipment.
- Annual saving = existing annual energy cost with old equipment's - new annual

energy cost with energy conservation equipment.

Significance of Payback period = **(1 Mark)**

1. The most significant advantage of payback method is its simplicity.
2. It is easy way to compare several projects and then to choose the project which have shortage payback time.

OR Student may write this way

Definition Payback period: **(1Mark)**

It is the time required for an energy efficient method to cover its purchase, installation and running cost.

OR

Payback period is the time required to recover the funds invested in a project.

Procedure to calculate the payback period: **(2 Mark)**

A] Steps to calculate saving for Kw load

a) Calculation for old system:

i) Calculate load per day =(Consumption per fixture X Total fixture X working Hours) / 1000

ii) Calculate load per month = Load per day X Working days per month

iii) Calculate consumption per month= Load per month(kW) X unit rate(Rs/kW)

b) Calculations for proposed system:

i) Load per day = (Consumption per fixture X Total fixture X working Hours) / 1000

ii) Load per month = Load per day X Working days per month

iii) Consumption per month= Load per month(kW) X unit rate(Rs/kW)

c) Calculate cost saving per month :

(old system consumption per month) – (Proposed system consumption per month)

d) **Calculate cost saving per year** = 12 x Saving per month

B] Saving for VA load :

i) Calculation for old system:- Calculate VA = W / P.f.

Total kVA load for all the fixtures = VA x No of fixtures /1000

ii) Calculation for proposed system:-

Total kVA load for all the fixtures = VA x No of fixtures /1000

iii) Saving:

Total kVA load saving for all the fixtures = (Total kVA load of old system for all the fixtures) – (Total kVA load of proposed system for all the fixtures)

Monthly Demand charges saving = (Total kVA load saving for all the fixtures) x (Maximum demand charges per kVA in Rs.)

Yearly demand charges saving = 12 x (Monthly demand charges saving)

Calculations for Payback period in years:

i) Calculate total investment for new system

ii) Payback period in years = Investment / Total Saving

Significance of payback period: **(1 Mark)**

The payback period is an evaluation method used to determine the amount of time required for the cash flows from a project to pay back the initial investment in the project.

The most significant advantage of the payback method is its simplicity. It's an easy way to compare several projects and then to take the project that has the shortest payback time.

Q.5	**Attempt any TWO of the following :**	**12 Marks**
a) i)	**(i) State the significant feature of soft starter.**	
Ans:	**Significant features of soft starters:** **(Any THREE point expected: 1 Mark each)**	

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 suchas 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.

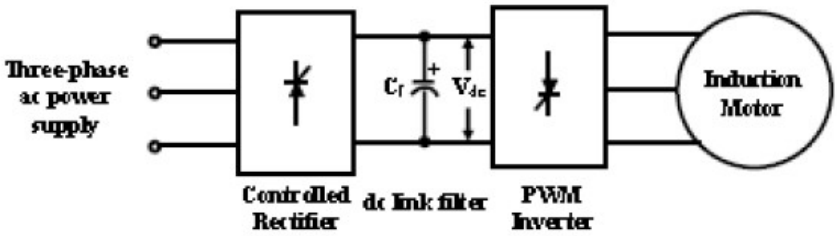
8) Less mechanical maintenance.
9) Saving in operating costs.
10) Better power factor
11) System efficiency increases.
12) Starting torque is less.

OR

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

a) ii) (ii) Describe variable frequency drive with suitable diagram.

Ans: **Variable frequency drive with suitable diagram:** **(3 Marks)**



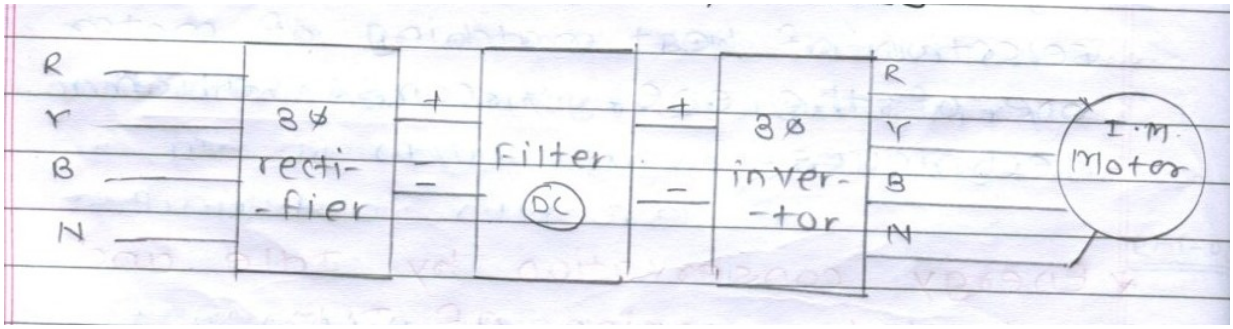
1. VFD changes the frequency of supply voltage to vary the speed of motor.
2. By adjusting the motor speed in such a way that matching of motor output to load can be achieved, which results in energy saving.
3. As shown in figure rectifier converts AC supply into DC supply. DC link filter is used to filter out ripples from rectifier output. Inverter is used to convert rectified DC supply into AC supply. Here V/F ratio is varied to get desired output.
4. Energy saving is possible due to optimum use for application.

5. Better process control is possible by using Micro controller and IGBT.

6. Less maintenance cost due to optimum working and due to low losses foe bearing and motor improves life span.

OR

Variable frequency drive with suitable diagram: **(3 Marks)**



- The variable frequency drives is a power electronic circuit in which 3-ph, 400V. 50 Hz AC supply is provided to the input side.
- This 3-ph ac supply is rectified and converted into pure dc output by using rectifier or converters.
- The output of this rectifier is provided to the input of 3-ph inverter by using the 3-ph inverter that pure dc is converted into 3-ph variable voltage, variable frequency output supply is provided input of induction motor.
- In the soft starting of I.M. the reduction voltage is applied to the input of I.M for smooth starting and after the starting as per requirement is applied.
- Due to this reduced voltage the starting current of I.M is less i.e. why power consumption is less. Hence we can of I.M is one of the energy conservation techniques.
- The induction motor always operates for constant torque operation below rated speed.
- For this case the frequency is reduced but voltage-frequency ratio is kept constant that is why the flux in the air gap of the I.M. will be constant i.e. why motor will operate at constant torque.
- As per the application if the speed control is required above rated speed then by increasing the frequency it is possible but at that time V/f ratio is not kept uniform of motor.
- SO as speed increases the torque will decreases. The output power of I.M remains constant.
- It is called as the constant HP operation of induction motor.

b)	**For the tariff of 125/kVA of maximum demand and 3.00 per unit consumed; load factor = 50%, find overall cost/unit at (i) unity power factor (ii) 0.8 p.f consider maximum demand = 10 kVA.**
Ans:	Given: Tariff = Rs. 125/kVA of maximum demand + 3.00 per unit consumed Load factor = 50 %, M. D. = 10 kVA **Monthly total charges/bill:** MD charges per month = (M.D. KvA x M.D. Charges per KvA) = 10 x 125 = Rs. 1250.00 Energy charges per unit = Rs. 3/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. **i) At Unity Power Factor:** **Average demand kW =** (load factor) x (maximum demand) x pf. = 0.5 x 10 x 1 = 5 kW. ---------- **(1/2 Marks)** **Energy consumption per month**: = average demand (kW) x (monthly hrs) = 5 x 720 = 3600 kWh. ---------- **(1/2 Marks)** **Energy consumption charges per month:** = (monthly energy consumed in kWh) x (charges per kWh) = 3600 x 3 = Rs. 10800 ---------- **(1/2 Marks)** **Total billing =** MD charges + energy charges = 1250 + 10800 = Rs. 12050. ---------- **(1/2 Marks)**

Overall cost per unit = (total bill) / (kWh for the month)

= 12050 / 3600

= Rs. 3.35/kWh. ---------- **(1 Marks)**

ii) At 0.8 pf :

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

= 0.5 x 10 x 0.8

= 4 kW. ---------- **(1/2 Marks)**

Energy consumption per month: = average demand(kW) x (monthly hrs)

= 4 x 720

= 2880 kWh. ---------- **(1/2 Marks)**

Energy consumption charges per month:

= (monthly energy consumed in kWh) x (charges per kWh)

= 2880 x 3

= Rs. 8640 ---------- **(1/2 Marks)**

Total billing = MD charges + energy charges

= 1250 + 8640

= Rs. 9890 ---------- **(1/2 Marks)**

Overall cost per unit = (total bill) / (kWh for the month)

= 9890 / 2880

= Rs. 3.43 /kWh. ---------- **(1 Marks)**

OR

Given:

Tariff = Rs. 125/kVA of maximum demand + 3.00 per unit consumed

Load factor = 50 %, M. D. = 10 kVA

Yearly total charges/bill:

MD charges per Bill = (M.D. KvA x M.D. Charges per KvA x 12)

= 10 x 125 x 12 = Rs. 15000

Energy charges per unit = Rs. 3/kWh.

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

Energy consumption charges per year:

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

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

The number hours in a year is = 8760 hr.

i) At Unity Power Factor:

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

= 0.5 x 10 x 1

= 5 kW. ---------- **(1/2 Marks)**

Energy consumption per year: = average demand (kW) x (year hrs)

= 5 x 8760

= 43800 kWh. ---------- **(1/2 Marks)**

Energy consumption charges per year:

= (Yearly energy consumed in kWh) x (charges per kWh)

= 43800 x 3

= Rs. 131400 ---------- **(1/2 Marks)**

Total billing = MD charges + energy charges

= 15000 + 131400

= Rs. 146400. ---------- **(1/2 Marks)**

Overall cost per unit = (total bill) / (kWh for the Bill)

= 146400 / 43800

= Rs. 3.35/kWh. ---------- **(1 Marks)**

ii) At 0.8 pf :

Yearly total charges/bill:

MD charges per Bill = (M.D. KvA x M.D. Charges per KvA x 12)

= 10 x 125 x 12 = Rs. 15000

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

= 0.5 x 10 x 0.8

= 4 kW. ---------- (1/2 Marks)

Energy consumption per year: = average demand(kW) x (year hrs)

= 4 x 8760

= 35040 kWh. ---------- (1/2 Marks)

Energy consumption charges per year:

= (year energy consumed in kWh) x (charges per kWh)

= 35040 x 3

= Rs. 105120 ---------- (1/2 Marks)

Total billing = MD charges + energy charges

= 15000 + 105120

= Rs. 120120 ---------- (1/2 Marks)

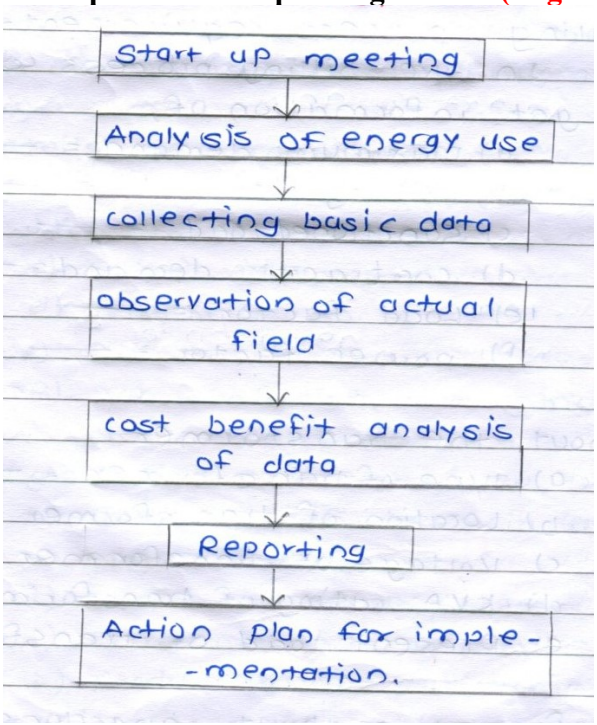
Overall cost per unit = (total bill) / (kWh for the year)

= 120120 / 35040

= Rs. 3.43 /kWh. ---------- (1 Marks)

c) Explain with flow chart the energy audit procedure.

Ans: **Detailed energy audit procedure Depending:** **(Figure : 3 Mark & Explanation : 3 Mark)**



or equivalent figure

A) **Start up meeting**: Procedure starts with start up meeting. Then it continue until implementation of energy saving measures.

B) **Analysis of energy used**: Identify where energy used & it shows on which area should be concentrate.

C) **Collecting basic data:** At site load, some of the following important points:

1.Operating hours 2.Duty cycle 3.Actual power consume

D) **Observation of actual field**: After collecting data, we start actual field work. It means we have find out process where energy saving can be done. Always apply the 80 by 20 rule.

E) **Cost benefit analysis of the data:** This Analysis is in the terms of cost of carrying out that project v/s the benefit that can be earned.

F) **Reporting:** We have to submit the detail report. Then we have to take sanction of that report from final Authority.

G) **Action plan**: In this all the measure steps must be included in the action plan for the proper implementation.

OR

1. **Collect information about the plan:**
   In this information, the measured energy used, raw material required & components required for the plant are considered.
2. **Collect production process:**
   In this process, the design the flowchart of production process, the schedule of operation & its time frame is also considered.
3. **Energy and utility system**:
   In this step, load variation in pumps, fans & compressors are considered, the analysis of energy loss and measurement of insulation level is also considered.
4. **Bridge description of each utility**:
   In this step, the electricity the steam, water, cooling water an compressed air is to be considered.
5. **Detailed process flow diagram:**
   In this step the flow chart, the flow rate & boiler efficiency is to be considered.
6. **Energy efficiency in utility & process system**:
   In this step, consider the following things i) specific energy consumption ii) furnace iii) DG set performance analysis iv) lighting system.
7. **Energy conservation option & recommendation:**
   The energy conservation & recommendation of better energy source is to be considered.

OR **(Any Six point expected: 1 Mark each)**

1) Depending on the nature and complexity of the organization, a comprehensive audit can take from several weeks to several months to complete.

2) Detail studies to establish and investigate energy & materials balances for specific organization departments of process equipment are carried out.

3) Whenever possible checks of organization operations are carried out over extended periods of time at nights and at weekends.

4) The audit report will include a description of energy inputs and product outputs by major departments & will evaluate the efficiency of each step of the manufacturing process.

5) The improve this efficiency will be listed and at least a preliminary assessments of the cost of the improvement will be made to indicate the expected payback on any capital investment needed.

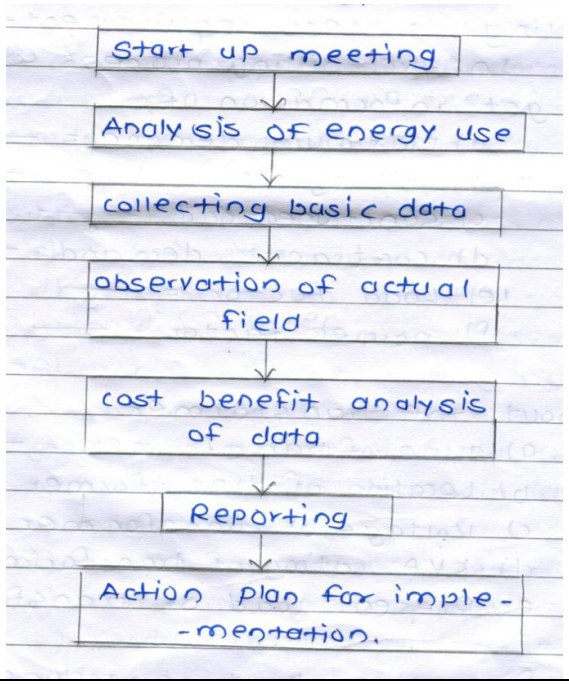
6) The audit report should conclude with specific recommendations for detailed engineering studies & feasibility analysis which must be performed to justify the implementation of those conservation measures that require investments.

Q.6 **Attempt any TWO of the following :** **12 Marks**

a) **Describe detailed energy audit procedure to be carried out for an organization.**

Ans: **Detailed energy audit procedure Depending:**

(Figure : 3 Mark & Explanation : 3 Mark)



A) **Start up meeting**: Procedure starts with start up meeting. Then it continue until implementation of energy saving measures.

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.OR

1. **Collect information about the plan:**

In this information, the measured energy used, raw material required & components required for the plant are considered.

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7. **Energy conservation option & recommendation:**

The energy conservation & recommendation of better energy source is to be considered.

OR **(1 Mark each Point)**

1) Depending on the nature and complexity of the organization, a comprehensive audit can take from several weeks to several months to complete.

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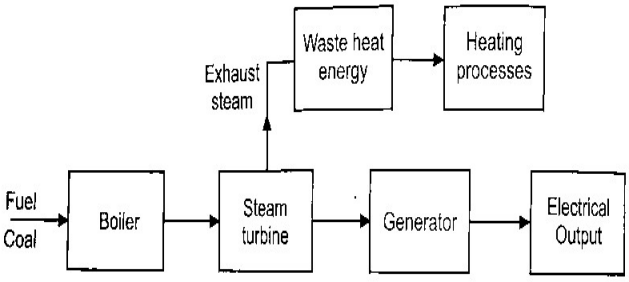
b) Explain with diagram : (i) Topping cycle type of cogeneration (ii) Bottoming type of cogeneration

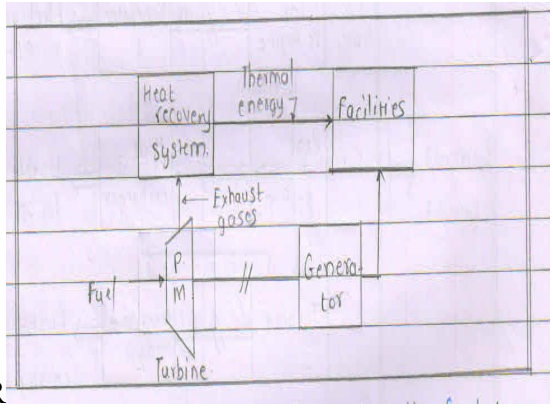
Ans:

i) Topping cycle cogeneration system: **(Figure :1 Mark & Explanation : 2 Mark)**



Topping cycle co-generation system

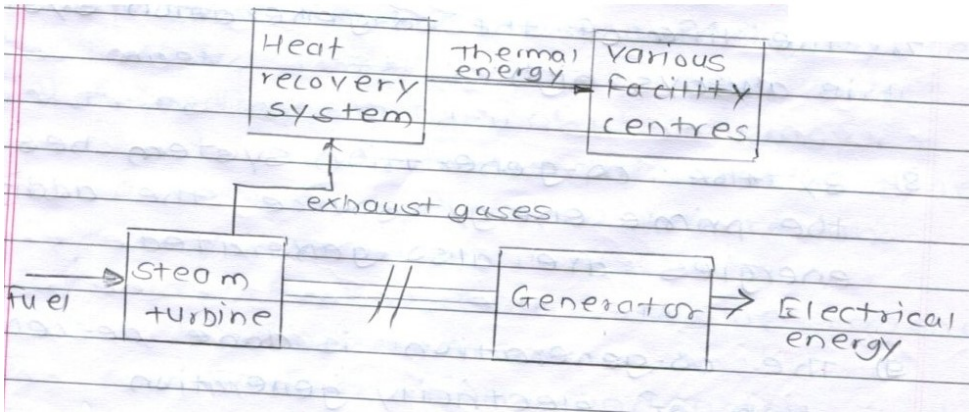
OR



or equivalent figure

- 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).
- In Topping cycle co-generation system the fuel is burnt for electricity generation.
- At the time of fuel burning process the excess thermal energy present in the system is recovered by heat recovery system and it is utilized.
- The topping cycle co-generation system is popular method and it is widely used.

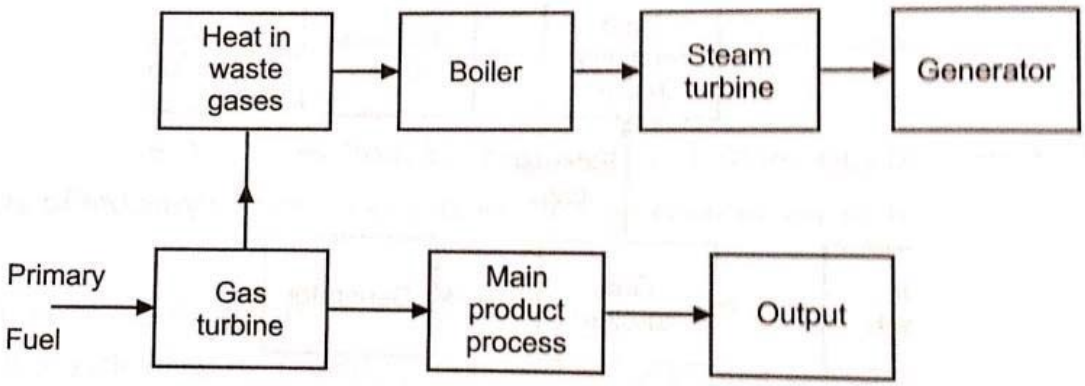
OR



or equivalent figure

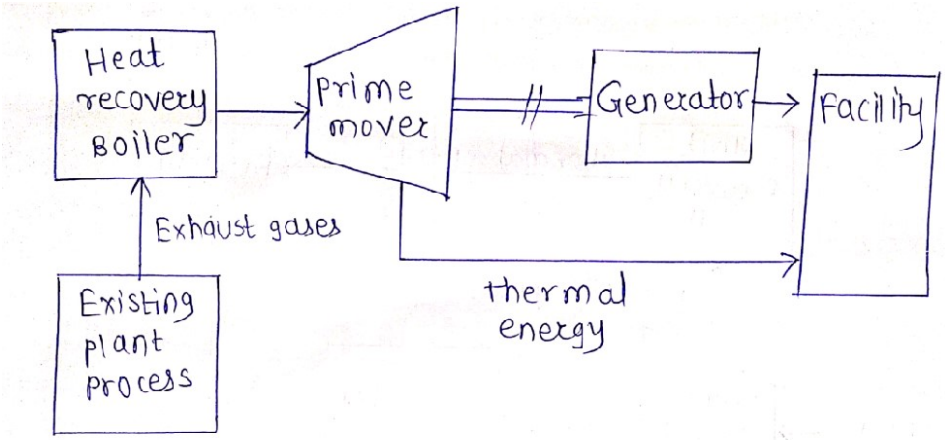
- The block diagram is as shown in figure. In the topping cycle co-generation system. The fuel is burnt to get the electrical energy first and wastages are converted to get the thermal energy.
- As per the black diagram the fuel is burnt in the boiler to get the high pressure high temperature steam which is carried through steam turbine, so steam turbine is prime mover.
- Which is coupled to the generator, to get the electrical energy. The exhaust gases after the steam turbine are provided to the heat recovery system in which high temperature thermal energy is obtained to provide the various facilities in which the thermal energy is required.
- So, as per this block diameter electrical energy is obtained in stage no.1 and thermal energy is obtained in stage no.2.

ii) Bottoming cycle cogeneration system: **(Figure :1 Mark & Explanation : 2 Mark)**



Bottoming cycle co-generation system

OR



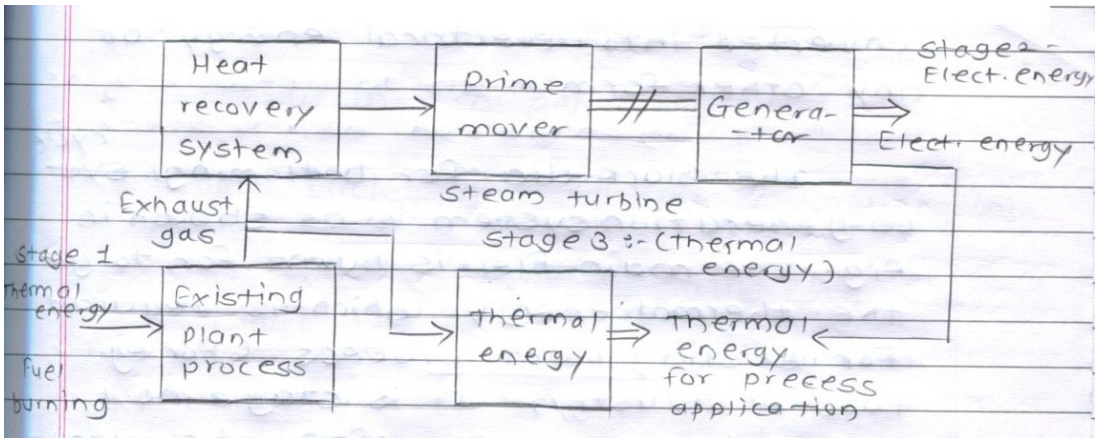
OR equivalent figure

1) Bottoming cycle of co-generation system is that in which high temperature heat energy is produced using primary fuels.
2) This heat produced is mainly used for other processes except generation of electricity.
3) Rejected heat from process is utilized to generate electricity.
4) The rejected heat is taken from recovery boiler and it is then applied to the turbine connected to the generator to produce electricity.
5) From manufacturing process of some products heat at high temperature is required in furnaces and kilns.

6) 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.

7) Bottoming cycles are suitable for cement industries, ceramic factories etc.

OR



- The main purpose of bottoming cycle co-generation system is to get the thermal energy after burning of fuel.
- The exhaust of remaining energy is converted into electrical energy or any other form.
- The block diagram for bottoming cycle co-generation system is as shown in figure. The main fuel is burnt to get the thermal energy which is required for existing plant process (for rg. Food industry)
- It is stage No.1 the exhaust gases after the plant process are passed to the heat recovery system in which high pressure, high temperature steam is generated and which is passed on the steam turbine.
- The steam turbine is coupled to the generator to get the electrical energy in the stage no.2. The excesses exhaust gases or thermal energy after the plant process is directly provided to the various process applications. It is stage no.3 .
- Sometimes electrical energy is also used to get the thermal energy for process applications.

c)	**Explain the following energy conservation technique : (i) Controlling I^2R losses (ii) Balancing phase current**
Ans:	**i) By reducing I^2R losses in Trans: (Any 3 points)** **(3 Marks)** 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) 4. Use of voltage controllers to maintain the voltage level at rated levels (not allowing the voltage to fall that leads to higher line currents) 5. Marinating proper distance (as low as economically possible) between consumer and distribution transformer. 6. Skin effect will increase resistance of conductor so I^2R losses will be more due to skin effect. **(ii) Balancing Phase currents: (Any 3 points)** **(3 Mark)** ➢ 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. ➢ 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. ➢ 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. Hence it is necessary to obtain current balance to the maximum.

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