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Internal Assesment Test - II

Sub:	ENERGY AUDITING & DEMAND SIDE MANAGEMENT							Code:	10EE831
Date:	16/04/2018	Duration:	90 mins	Max Marks:	50	Sem:	8th	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE	
			CO	RBT
1 a)	What is energy use profile?	[5]	CO2	L1
b)	What are the various auditing required for developing energy profile.	[5]	CO2	L1
2	Write short notes on energy audit instruments. Explain each one of them.	[10]	CO2	L4
3	Give the ten methodology steps for detailed energy auditing and explain.	[10]	CO2	L4
4	Explain the steps in energy audit report generation.	[10]	CO2	L4
5 a)	With vector diagram explain the various components of power triangle.	[6]	CO3	L4
b)	Explain motor horsepower.	[4]	CO3	L4
6	What is power flow concept. Explain PEP and production factor.	[10]	CO3	L4
7	Write short notes on primary and secondary distribution.	[10]	CO3	L1

******All the Best*****

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ANSWER KEY

1a) ENERGY USE PROFILE (5 MARKS)

ENERGY USE PROFILE :

→ EA for a building audit emphasis is given to ventilation, heat-building envelope, air conditioning & lighting functions.

→ For an industrial audit emphasize on process considerations.

→ So it is important to know about total consumption, cost & how energy is used for each commodity in an industry like Steam, water, air & natural gas.

→ An appropriate Energy conservation strategy is made.

2

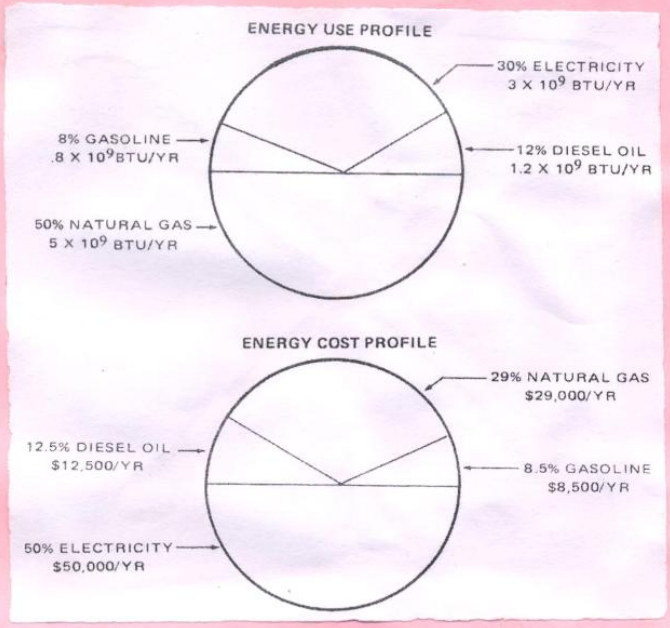


Fig 1. Energy use & cost Profile

* The 1st figure shows how much energy is used by each fuel type.
* 2nd figure shows how much is spent for each fuel type.

→ So either using a pie chart or nodal flow diagram

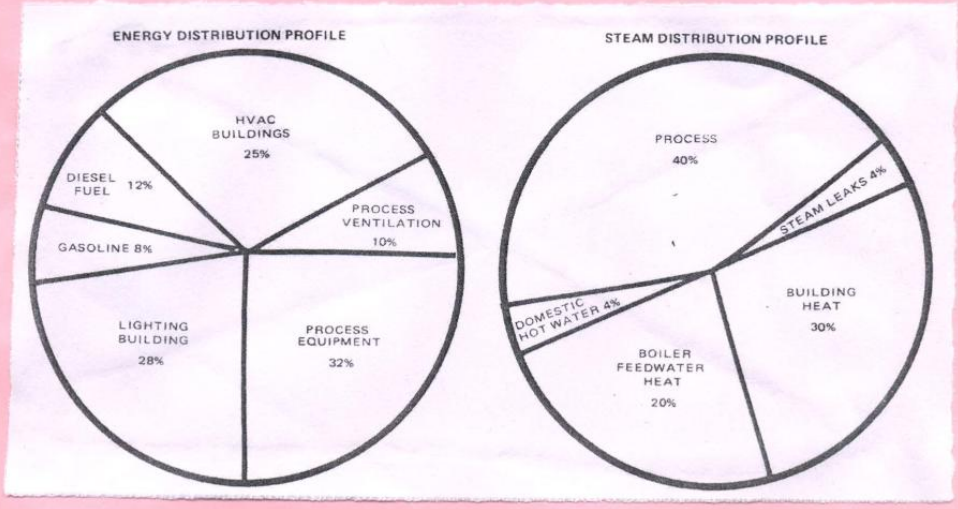


Fig 2. Energy profile by function

* Fig 2 on the other hand shows how much of energy is used for each function such as lighting, process and building heating & Ventilation etc.
* Fig on RHS shows Steam distribution profile.

* Figure 3 shows an alternate representation for steam distribution profile.

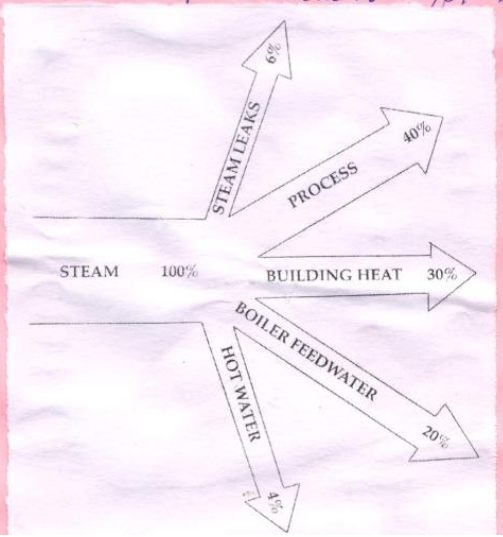


Fig: steam dist nodal diag.

1.B)AUDITS REQUIRED TO CONSTRUCT ENERGY USE PROFILE (5MARKS)

* To construct such energy use profiles, several audits are required to construct Energy use profile

① Envelope audit

It surveys the building envelope for losses or gains due to leaks, building construction, doors, glass, lack of insulation etc.

② Functional audit

→ Determines the amount of energy required for a particular function

→ identifies energy conservation opportunities

→ includes
- heating, ventilation & air-conditioning
- Building
- Lighting
- Domestic hot water
- air distribution

③ Process audit :

→ Determines the amount of Energy required for each process function

→ identifies the energy conservation opportunities.

→ Process functional audits include :

* Process machinery
* Heating, ventilation and air-conditioning process
* Heat treatment
* Furnaces

Transportation Audit :

* Audit determines the amount of energy required for forklift trucks, cars, vehicles, trucks etc.

*

Utility Audit :

The Audit Analyzes the monthly, daily or yearly energy usage for each utility.

3ans. ten step methodology of energy audit (10 marks)

Ten Steps Methodology for Detailed Energy Audit

Step No	PLAN OF ACTION	PURPOSE / RESULTS
	Phase I –Pre Audit Phase	
Step 1	• Plan and organise • Walk through Audit • Informal Interview with Energy Manager, Production / Plant Manager	• Resource planning, Establish/organize a Energy audit team • Organize Instruments & time frame • Macro Data collection (suitable to type of industry.) • Familiarization of process/plant activities • First hand observation & Assessment of current level operation and practices
Step 2	• Conduct of brief meeting / awareness programme with all divisional heads and persons concerned (2-3 hrs.)	• Building up cooperation • Issue questionnaire for each department • Orientation, awareness creation
	Phase II –Audit Phase	
Step 3	• Primary data gathering, Process Flow Diagram, & Energy Utility Diagram	• Historic data analysis, Baseline data collection • Prepare process flow charts • All service utilities system diagram (Example: Single line power distribution diagram, water, compressed air & steam distribution. • Design, operating data and schedule of operation • Annual Energy Bill and energy consumption pattern (Refer manual, log sheet, name plate, interview)
Step 4	• Conduct survey and monitoring	• Measurements : Motor survey, Insulation, and Lighting survey with portable instruments for collection of more and accurate data. Confirm and compare operating data with design data.
Step 5	• Conduct of detailed trials /experiments for selected energy guzzlers	• Trials/Experiments: - 24 hours power monitoring (MD, PF, kWh etc.). - Load variations trends in pumps, fan compressors etc.

		Equipments Performance experiments etc
Step6	• Analysis of energy use	• Energy and Material balance & energy loss/waste analysis
Step 7	• Identification and development of Energy Conservation (ENCON) opportunities	• Identification & Consolidation ENCON measures • Conceive, develop, and refine ideas • Review the previous ideas suggested by unit personal • Review the previous ideas suggested by energy audit if any • Use brainstorming and value analysis techniques • Contact vendors for new/efficient technology
Step 8	• Cost benefit analysis	• Assess technical feasibility, economic viability and prioritization of ENCON options for implementation • Select the most promising projects • Prioritise by low, medium, long term measures
Step9	• Reporting & Presentation to the Top Management	• Documentation, Report Presentation to the top Management.

Step10	Phase III –Post Audit phase • Implementation and Follow-up	Assist and Implement ENCON recommendation measures and Monitor the performance • Action plan, Schedule for implementation • Follow-up and periodic review

2ans) energy audit measuring instruments (10 marks- any 10 instruments)

Ammeter and Voltmeter

- To measure electrical currents, ammeters are used.
- For most audits, alternating currents are measured.
- Ammeters used in audits are **portable** and are designed to be easily attached and removed.
- There are many brands and styles of **snap-on ammeters** commonly available that can read up to 1000 amperes continuously. This range can be extended to 4000 amperes.(using CTS)
- The snap-on ammeters can be either **indicating or recording** with a printout.

- After attachment, the recording ammeter can keep recording current variations for as long as a full month on one roll of recording paper.
- This allows the study of current variations in a conductor for extended periods **without constant operator attention**.

- The second parameter required to calculate energy is voltage, and it is measured by a voltmeter.
- **A voltmeter measures the difference in electrical potential between two** points in an electrical circuit.
- The voltage drops measured in many instances are fairly constant and need only be performed once.
- If there are appreciable fluctuations, additional readings or the use of a **recording voltmeter may be indicated**.
- Most voltages measured in practice are under 600 volts and there are many portable voltmeter/ ammeter clamp-ons available for this and lower ranges.

Wattmeter and Power Factor Meter

- The portable wattmeter can be used to indicate by direct reading electrical energy in watts.
- It can also be calculated by measuring voltage, current and the angle between them (power factor angle).
- The basic wattmeter consists of three voltage probes and a snap-on current coil which feeds the wattmeter movement.
- The typical operating limits are 300 kilowatts, 650 volts, and 600 amperes.
- It can be used on both one- and three-phase circuits
- The portable **power factor meter** is primarily a three-phase instrument.
- One of its three voltage probes is attached to each conductor phase and a snap-on jaw is placed about one of the phases.
- By disconnecting the wattmeter circuitry, it will directly read the power factor of the circuit to which it is attached.
- It can measure **power factor over a range of 1.0 leading to 1.0 lagging** with "ampacities" up to 1500 amperes at 600 volts.
- This range covers the large bulk of the applications found in light industry and commerce.
- Continuous displays or intermittent alternating displays are available at the touch of a button .

FOOTCANDLE METER

- Footcandle meters measure **illumination in units of footcandles** through a light-sensitive barrier layer of cells contained within them.
- They are usually pocket-size and portable and are meant to be used as field instruments to survey levels of illumination.
- These meters differ from conventional photographic lightmeters in that they are color and cosine corrected.

TEMPERATURE MEASUREMENTS

1. Thermometer

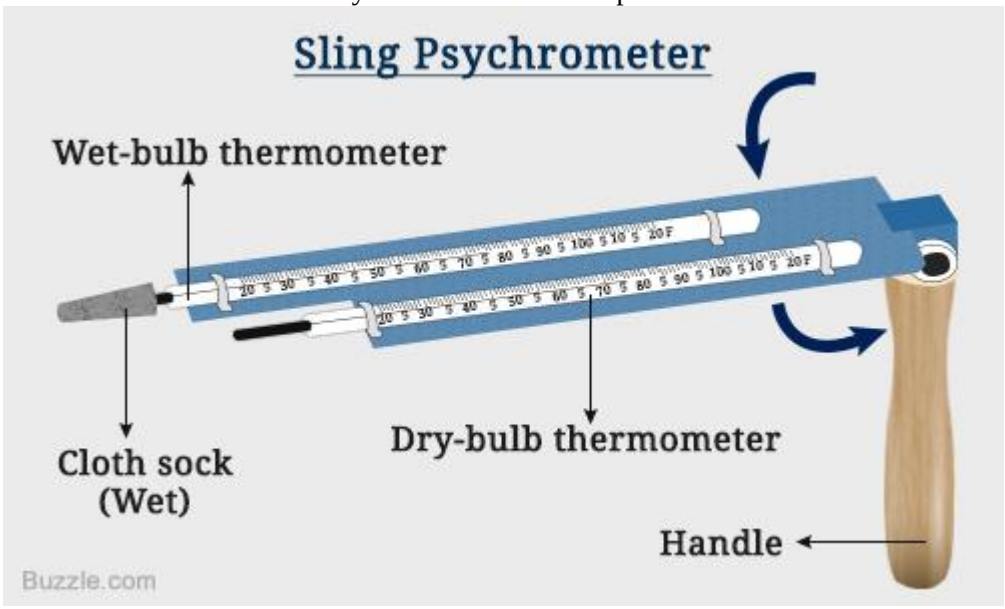
- There are **many types** of thermometers that can be used in an **energy audit.**
- The choice of what to use is usually dictated by cost, durability, and application.
- For air-conditioning, ventilation and hot-water service applications (temperature ranges 50°F to 250"F), a multipurpose portable battery-operated thermometer is used.
- Three separate probes are usually provided to measure liquid, air or surface temperatures.
- For boiler and oven stacks (1000°F) a dial thermometer is used.
- **Thermocouples** are used for measurements **above 1000°F.**

Surface Pyrometer

- Surface pyrometers are instruments which measure the **temperature of surfaces.**
- They are somewhat **more complex** than other temperature instruments because their **probe** must make **intimate contact** with the surface being measured.
- Surface pyrometers are of immense help in assessing **heat losses through walls** and also for testing steam traps.
- They may be divided into two classes: **low-temperature (up to 250°F) and high-temperature (up to 600°F to 700°F).**
- The low-temperature unit is usually part of the multipurpose thermometer kit. The high-temperature unit is more specialized but needed for evaluating fired units and general steam service.
- There are also **noncontact surface pyrometers** which measure infrared radiation from surfaces in terms of temperature.
- These are suitable for **general work** and also for measuring surfaces which are visually but not physically accessible.
- A more specialized instrument is the **optical pyrometer.** This is for high-temperature work (above 1500°F) because it measures the temperature of bodies which are incandescent because of their temperature.

Psychrometer

- A psychrometer is an instrument which measures relative humidity based on the relation of the dry-bulb temperature and the wetbulb temperature.
- Relative humidity is of prime importance in WAC and drying operations.
- Recording psychrometers are also available.
- Above 200°F humidity studies constitute a specialized field of endeavor.

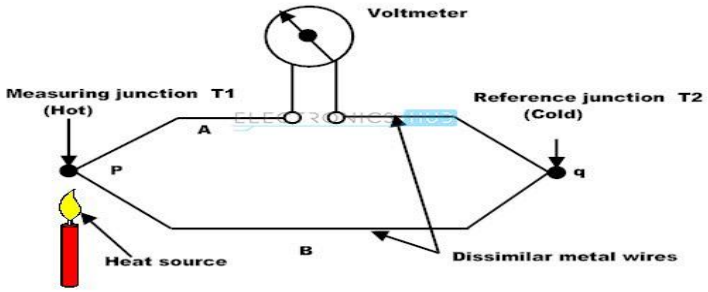


Portable Electronic Thermometer

- The portable electronic thermometer is an adaptable temperature measurement tool.

- The battery-powered basic instrument, when housed in a carrying case, is suitable for laboratory or industrial use.
- A **pocket-size digital**, battery-operated thermometer is especially convenient for spot checks or where a number of rapid readings of process temperatures need to be taken.

Thermocouple Probe



- A **Thermocouple** is a sensor used to measure temperature.
- **Thermocouples** consist of **two wire legs** made from **different metals.**
- The wires legs are welded together at one end, creating a **junction.**
- This junction is where the **temperature is measured**.
- No matter what sort of indicating instrument is employed, the thermocouple used should be carefully selected to match the application.
- It should be properly positioned if a representative temperature is to be measured.
- The same care is needed for all sensing devices-thermocouple, bimetals, resistance elements, fluid expansion, and vapor pressure bulbs.

Suction Pyrometer

- **Suction pyrometers** consist of a combination of a thermocouple and a **suction probe** for gas samples
- Errors arise if a normal sheathed **thermocouple** is used to measure gas temperatures, especially high ones.
- The suction pyrometer overcomes these by shielding the thermocouple from wall radiation and drawing gases over it at high velocity to ensure good convective heat transfer.
- The thermocouple thus produces a reading which approaches the true temperature at the sampling point rather than a temperature between that of the walls and the gases.

MEASURING COMBUSTION SYSTEMS

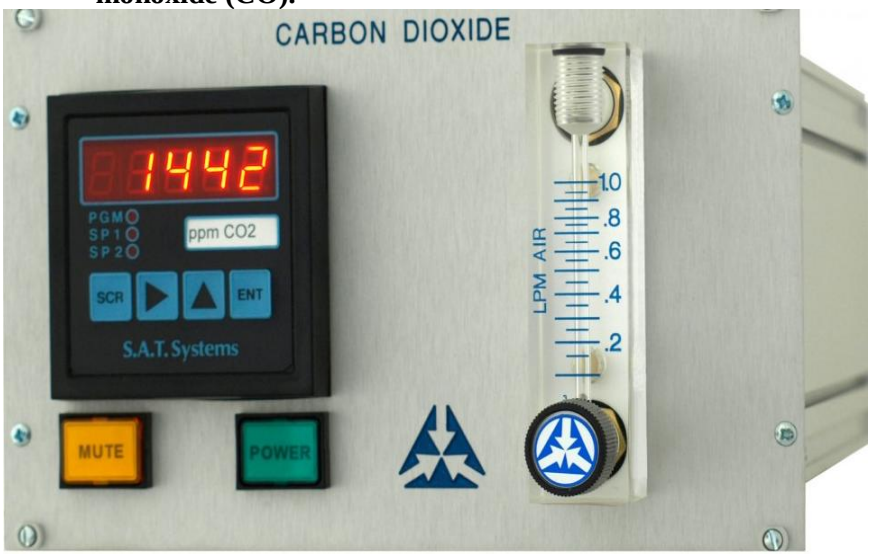
Combustion Tester

- Combustion testing consists of **determining the concentrations** of the **products of combustion** in a stack gas.
- The products of combustion usually considered are **carbon dioxide** and **carbon monoxide**.

- Oxygen is tested to assure proper excess air levels.
- The definitive test for these constituents is an **Orsat apparatus**.
- This test consists of taking a measured volume of stack gas and measuring successive volumes after intimate contact with selective absorbing solutions.
- The reduction in volume after each absorption is the measure of each constituent.

Boiler Test Kit

- The boiler test kit contains the following:
  - **CO_2 Gas analyzer**
  - **0_2 Gas analyzer**
  - **CO Gas analyzer**
- The purpose of the components of the kit is to help **evaluate fireside boiler operation**.
- Good combustion usually means **high carbon dioxide, low oxygen, and little or no trace of carbon monoxide (CO).**



Gas Analyzers

- The gas analyzers are usually of the **Fyrite type.**
- The Fyrite type differs from the Orsat apparatus in that it **is more limited** in application and **less accurate**.
- The chief advantages of the Fyrite are that it is **simple and easy to use** and is **inexpensive**.
- This device is used many times in an energy audit.
- **Three readings** using the Fyrite analyzer should be made and the **results averaged.**

Draft Gauge

- The draft gauge is used to measure pressure.
- It can be the pocket type or the inclined manometer type.

Smoke Tester

- To measure combustion completeness the smoke detector is used.
- Smoke is **unburned carbon**, which wastes fuel, causes air pollution, and fouls heat-exchanger surfaces.
- To use the instrument, a measured volume of flue gas is drawn through filter paper with the probe.
- The **smoke spot is compared visually with a standard scale** and a measure of **smoke density** is determined.

Combustion Analyzer

- The combustion electronic analyzer permits fast, close adjustments.
- The unit contains digital displays.
- A standard sampler assembly with probe allows for stack measurements through a single stack or breaching hole.

MEASURING HEATING, VENTILATION SYSTEM PERFORMANCE AND AIR-CONDITIONING

Air Velocity Measurement

Smoke pellets-

- *limited use but very low cost.*
- *Considered to be useful* if engineering staff has experience in handling.

Anemometer (deflecting vane)-

- good indication of air movement with acceptable order of accuracy.
- Considered useful (approximately $50).

Anemometer (revolving vane) –

- good indicator of air movement with acceptable accuracy.
- However, easily subject to damage.
- Considered useful (approximately $100).

Pitot tube-

- *a standard air measurement device with good levels of accuracy.*
- Considered essential.
- Can be purchased in various lengths-**12" about $20,48" about $35.**
- **Must be used with a monometer.**
- **These** vary considerably in cost, but could be on the order of $20 to $60.

Impact tube-

- usually packaged air flow meter kits, complete with various jets for testing ducts, grills, open areas, etc.
- These units are convenient to use and of sufficient accuracy.
- The costs vary around $150 to $300, and therefore this order of cost could only be justified for a large system.

4ans:

Report on

DETAILED ENERGY AUDIT

TABLE OF CONTENTS

4.0 Detailed Process flow diagram and Energy& Material balance

4.1 Flow chart showing flow rate, temperature, pressures of all input-output streams

4.2 Water balance for entire industry

5.0 Energy efficiency in utility and process systems

5.1 Specific Energy consumption

5.2 Boiler efficiency assessment

5.3 Thermic Fluid Heater performance assessment

5.4 Furnace efficiency Analysis

5.5 Cooling water system performance assessment

5.6 DG set performance assessment

5.7 Refrigeration system performance

5.8 Compressed air system performance

5.9 Electric motor load analysis

5.10 Lighting system

6.0 Energy Conservation Options & Recommendations

6.1 List of options in terms of No cost/ Low Cost, Medium cost and high investment Cost, Annual Energy & Cost savings, and payback

6.2 Implementation plan for energy saving measures/Projects

ANNEXURE

A1. List of Energy Audit Worksheets

A2. List of instruments

A3. List of Vendors and Other Technical details

5ANS:

THE POWER TRIANGLE :

* Total Power requirement of a load is divided into 2 components namely Resistive part & Reactive part.

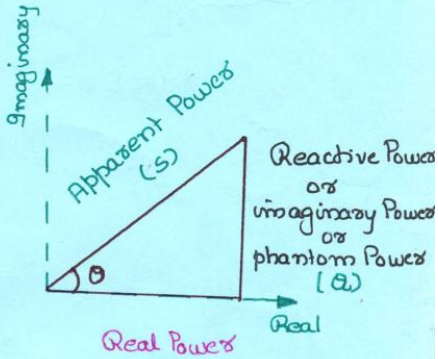
* Resistive portion of the load cannot be directly added with the reactive component because both are nearly 90° out of phase with each other.

- The pure resistive portion is known as Watt.

→ This part is associated with the Real Power (P).

$$P = VI \cos\theta \text{ (watts)}$$

→ Also known as Active Power or True Power.



Real Power or Active Power or True Power (W)

→ Active Power is the power dissipated and used to run motors, lights etc.

- The pure reactive component of Power is reffered to as Volt-Ampere Reactive (Q)

$$Q = VI \sin\theta \text{ (VAR)}$$

→ Reactive Power is the power absorbed by the elements.

→ Also known as Imaginary power, or phantom power.

* Now to compute the total load we have to analyze the power triangle.

→ From the power triangle we can say that total load Power is the Apparent Power. (S)

→ So Apparent Power is the sum of power dissipated & Power absorbed.

$$S = VI \quad (VA)$$ unit → Volt Ampere

∴ θ in figure is the angle between KVA or VA & kW or W.

where k = 1000

So $\cos\theta$ = Power factor

$$\tan\theta = \frac{kVAR}{kW}$$

We can also write few more equations :

Active Power, $P = I^2R$ (Watts or kW)

Reactive Power, $Q = I^2X$ (VAR or kVAR)

Apparent Power, $S = I^2Z$ (VA or kVA)

5b)motor horse power

MOTOR HORSE POWER :

* The standard power rating of a motor is referred to as a horse - power.

$$1hp = 745.6998715822 7\ W$$

* To relate motor Horse power to kVA the relation is as follows :

$$kVA = \frac{HP \times 0.746}{\eta \times P.f}$$

HP → motor horse power
η → Efficiency of motor
Pf → Power factor of motor

* Motor η & P.f vary with the load.

6ANS:

PLANT ENERGY PERFOMANCE : (PEP)

* An Evaluation of the actual performance of a plant systems and equipments is needed.
* Plant systems & equipments are compared against the designed performance level or the best available technology.
* This difference is the potential for Energy savings.
* So Plant Energy performance study is a proven methodology to identify potential Energy savings and develop economically justified investment programs.
* PEP is the measure of whether a plant is now using more or less Energy than it did in the past.
* It is a performance indicator of Energy management programmes.

* It keeps one year as reference year and check the performance of further years.
* Thus it gives significant information about plant Energy use.
* The improvement or deleterioration from the reference year is called ENERGY PERFOMANCE.
* $$PEP = \frac{(\text{Reference year equivalent} - \text{current year Energy})}{\text{Reference year equivalent}} \times 100$$
* PEP is directly proportional to improvement in Energy management.

Servie activities of PEP:

① information gathering: Prior to onsite work, the consultant will request and Review a list of base plants.

② Evaluation & Site Survey: An evaluation of all the process operations, constraints, cost and existing performance will be conducted.

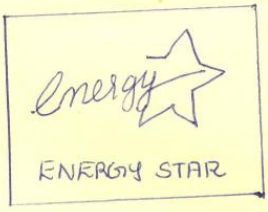
③ opportunity identification: An investigation is done to identify the best potential Energy improvement source and to project all the economic gains will be performed.

④ Offsite Analysis & Report: A detailed report of the recommendations will be generated.

⑤ Report transmittal and follow up: A final report will be delivered and follow-up meetings are sheduled to review and discuss the report.

Service objectives :

① Identify Energy savings
② Develop plans
③ Provide financial support for project implementation.



is a benchmark to analyse energy management.

PRODUCTION FACTOR

* Ratio of production in current year to that in reference year.
* Production factor = $\frac{\text{Current year production}}{\text{Reference year production}}$

POWER FLOW CONCEPT:

POWER FLOW CONCEPT

* Power flow is analogous to water flowing in a pipe.
* To supply several small water users, water is supplied from large pipe services at high pressure.
* Similarly a large feeder at high voltage services a plant.
* Through Switch gear breakers main feeder is distributed into smaller feeders.

* Electrical supply system deals with transmission & distribution syste
* Remotely generated power has been brought to load centres through trans-mission lines & then distributed.
* Transmission network is mostly HV or EHV level.
* OH line conductors on steel towers are mostly utilised for bulk power transmission.
* The distribution network comprises of Underground cables as feeders & distributors.
* They distribute power to service mains in consumer premises.

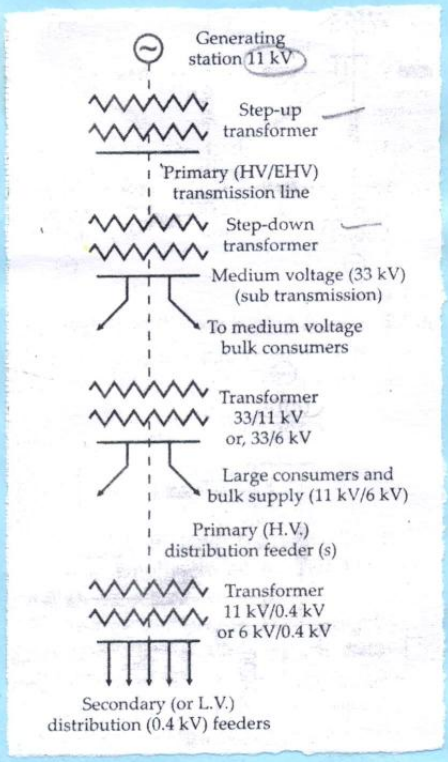


Fig: 4.2 Power System layout

7ANS:

STRUCTURE OF POWER TRANSMISSION SYSTEMS

* Power System is divided into many subsystems based upon operating voltage level.
* Highest voltage scale is the transmission network. (grid) Sub-Xmission & distribution s/m voltage levels occupy the subsequent places in descending order of voltage scale

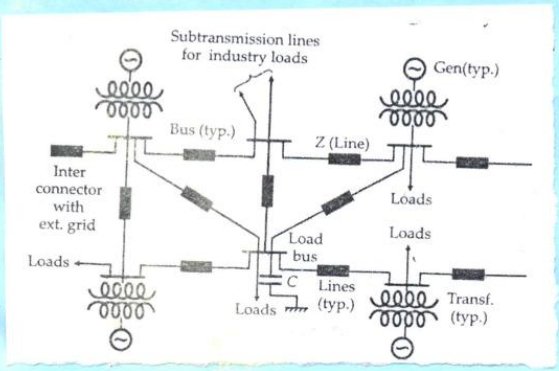


Fig:1 Typical Mesh type P s/m.

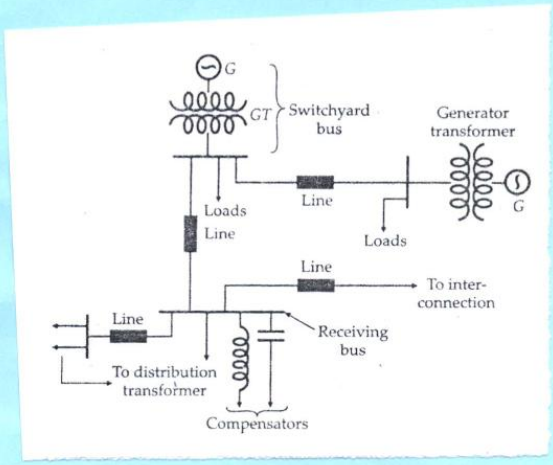


Fig 2: Radial Power System

* Figures shows the Single line diagram of (SLD) typical power networks.

* A Loop or mesh is shown in fig 1. network nodes are reffered as buses. Power s/m has usually generating stations, transformers, transmission lines, loads, interconnectors & compensating devices.

* The Nodal strength (short circuit capacity) of radial networks is generally low, while that for mesh it is high.

* So a mesh type network is considered as Robust network.

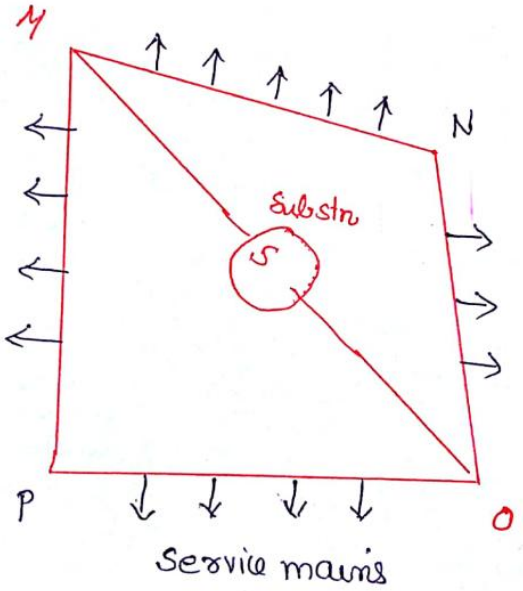
* Also the reliability of loop n/w is high as in structure because many alternative power flow routes are available.

* Loads are prime source of Power taps.

* Reactive control can be provided by introducing shunt inductors or capacitors connected to individual buses.

Electrical Power Dist s/m

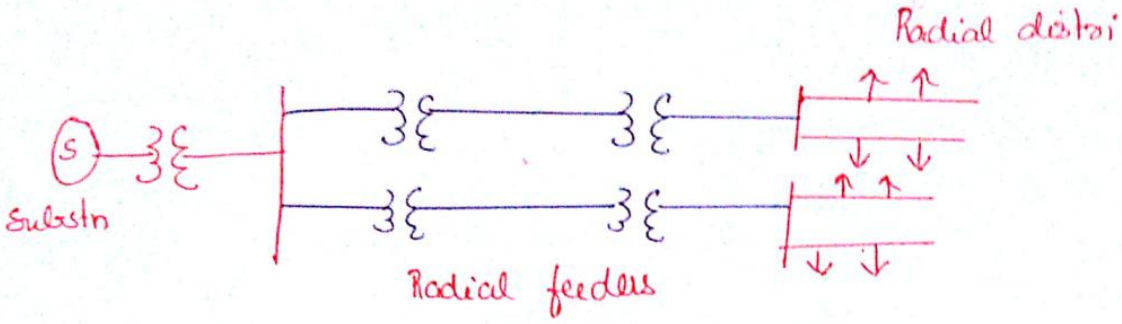
* Provide Power to individual consumers premises.
* Low Voltage level



SM, SO = feeder

MPO, MNO = distributors

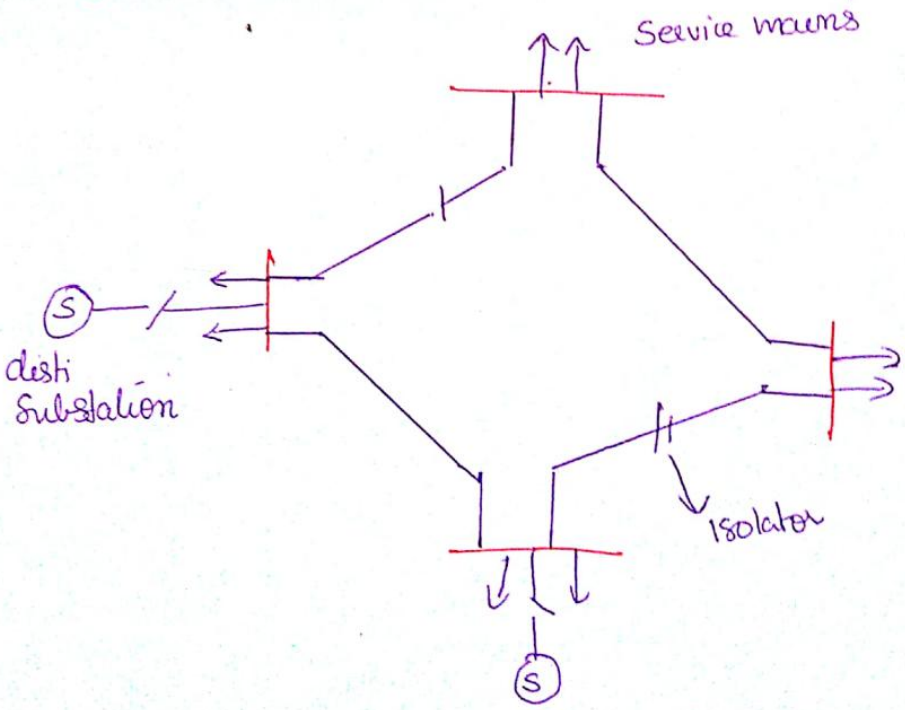
Radial Electrical Power Distribution system :



Drawback :

* Any feeder failure
* Transformer failure
* More time in darkness

Ring Main dist s/m



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