E- NOTES OF EECM (DIPLOMA 6TH SEM- EE)

Ch-1- Lighting System

Lux:- The **lux** is the SI derived unit of illuminance, measuring luminous flux per unit area. It is equal to one lumen per square metre. In photometry, this is used as a measure of the intensity, as perceived by the human eye, of light that hits or passes through a surface. It is analogous to the radiometric unit watt per square metre, but with the power at each wavelength weighted according to the luminosity function, a standardized model of human visual brightness perception.

Lumens:- The **lumen** is the SI derived unit of luminous flux, a measure of the total quantity of visible light emitted by a source per unit of time.Lumens are related to lux in that one lux is one lumen per square meter.

The lumen is defined in relation to the candela as

$$1\ \text{lm} = 1\ \text{cd} \cdot \text{sr}.$$

Illumination:- When light falls on a surface, it becomes visible, the phenomenon is called as **illumination**. It is defined as luminous flux falling on a surface per unit area. It is denoted by E and measured in lumen per square meter or meter- candle.

Space to height ratio:- Spacing Height Ratio is defined as the **ratio** of the distance between adjacent luminaires (centre to centre), to their **height** above the working plane.

Different types of lamps and their features:-

1. Incandescent lamps:- An incandescent light bulb, incandescent lamp or incandescent light globe is an electric light with a wire filament heated until it glows. The filament is enclosed in a bulb to protect the filament from oxidation. Current is supplied to the filament by terminals or wires embedded in the glass. A bulb socket provides mechanical support and electrical connections.

Incandescent bulbs are manufactured in a wide range of sizes, light output, and voltage ratings, from 1.5 volts to about 300 volts. They require no external regulating equipment have low manufacturing costs and work equally well on either alternating current or direct current. As a result, the incandescent bulb became widely used in household and commercial lighting, for portable lighting such as table lamps, car headlamps, and flashlights, and for decorative and advertising lighting.

Incandescent bulbs are much less efficient than other types of electric lighting, converting less than 5% of the energy they use into visible light. The remaining energy is lost as heat. The luminous efficacy of a typical incandescent bulb for 120 V operation is 16 lumens per watt, compared with 60 lm/W for a compact fluorescent bulb or 150 lm/W for some white LED lamps.

Some applications use the heat generated by the filament. Heat lamps are made for uses such as incubators, lava lamps, and the Easy-Bake Oven toy. Quartz tube lamps are used for industrial processes such as paint curing or for space heating.

Incandescent bulbs typically have short lifetimes compared with other types of lighting; around 1,000 hours for home light bulbs versus typically 10,000 hours for compact fluorescents and 20,000–30,000

hours for lighting LEDs. Incandescent bulbs can be replaced by fluorescent lamps, high-intensity discharge lamps, and light-emitting diode lamps (LED). Some areas have implemented phasing out the use of incandescent light bulbs to reduce energy consumption.

2. Tungsten halogen lamps:-A **halogen lamp**, also known as a **tungsten halogen**, **quartz-halogen** or **quartz iodine lamp**, is an incandescent lamp consisting of a tungsten filament sealed into a compact transparent envelope that is filled with a mixture of an inert gas and a small amount of a halogen such as iodine or bromine. The combination of the halogen gas and the tungsten filament produces a halogen cycle chemical reaction which redeposits evaporated tungsten to the filament, increasing its life and maintaining the clarity of the envelope. This allows the filament to operate at a higher temperature than a standard incandescent lamp of similar power and operating life, this also produces light with higher luminous efficacy and color temperature. The small size of halogen lamps permits their use in compact optical systems for projectors and illumination. The small glass envelope may be enclosed in a much larger outer glass bulb for a bigger package, the outer jacket will be at a much lower and safer temperature, and it also protects the hot bulb from harmful contamination and makes the bulb mechanically more similar to a conventional lamp that it might replace.

3. Fluorescent lamps: A **fluorescent lamp**, or **fluorescent tube**, is a low-pressure mercury-vapor gas-discharge lamp that uses fluorescence to produce visible light. An electric current in the gas excites mercury vapor, which produces short-wave ultraviolet light that then causes a phosphor coating on the inside of the lamp to glow. A fluorescent lamp converts electrical energy into useful light much more efficiently than incandescent lamps. The typical luminous efficacy of fluorescent lighting systems is 50–100 lumens per watt, several times the efficacy of incandescent bulbs with comparable light output.

Fluorescent lamp fixtures are more costly than incandescent lamps because they require a ballast to regulate the current through the lamp, but the lower energy cost typically offsets the higher initial cost. Compact fluorescent lamps are now available in the same popular sizes as incandescents and are used as an energy-saving alternative in homes.

Because they contain mercury, many fluorescent lamps are classified as hazardous waste. The United States Environmental Protection Agency recommends that fluorescent lamps be segregated from general waste for recycling or safe disposal, and some jurisdictions require recycling of them.

4. Mercury vapour lamp:- A **mercury-vapor lamp** is a gas discharge lamp that uses an electric arc through vaporized mercury to produce light. The arc discharge is generally confined to a small fused quartz arc tube mounted within a larger borosilicate glass bulb. The outer bulb may be clear or coated with a phosphor in either case, the outer bulb provides thermal insulation, protection from the ultraviolet radiation the light produces, and a convenient mounting for the fused quartz arc tube.

Mercury vapor lamps are more energy efficient than incandescent and most fluorescent lights, with luminous efficacies of 35 to 65 lumens/watt. Their other advantages are a long bulb lifetime in the range of 24,000 hours and a high intensity, clear white light output. For these reasons, they are used for large area overhead lighting, such as in factories, warehouses, and sports arenas as well as for streetlights. Clear mercury lamps produce white light with a bluish-green tint due to mercury's combination of spectral lines. This is not flattering to human skin color, so such lamps are typically not used in retail stores.

They operate at an internal pressure of around one atmosphere and require special fixtures, as well as an electrical ballast. They also require a warm-up period of 4 – 7 minutes to reach full light output.

Mercury vapor lamps are becoming obsolete due to the higher efficiency and better color balance of metal halide lamps.

5. Sodium vapour lamps:- A **sodium-vapor lamp** is a gas-discharge lamp that uses sodium in an excited state to produce light at a characteristic wavelength near 589 nm.

Two varieties of such lamps exist: *low pressure* and *high pressure*. Low-pressure sodium lamps are highly efficient electrical light sources, but their yellow light restricts applications to outdoor lighting, such as street lamps, where they are widely used. High-pressure sodium lamps emit a broader spectrum of light than the low-pressure lamps, but they still have poorer color rendering than other types of lamps. Low-pressure sodium lamps only give monochromatic yellow light and so inhibit color vision at night.

Energy efficient practices in lighting:- Energy efficient lighting reduces the electricity demand and is a cost effective method of lighting system compared to conventional lighting methods. In trending years, the gap between power generation figures and demand figures is a matter of concern, as it implies the failure of power supply system to meet the power demand, thus a warning about lack of conservation of energy.

Energy efficient lighting includes the use of more illumination from less power lights by replacing high power consumption lights like incandescent, high discharge lamps, etc. It is also replacing high power lighting accessories by low power devices such as electronic ballasts, fixtures, etc.

Replacing an ordinary bulb

In incandescent lamps, 90 percent of the electricity is wasted as heat rather than light and also 3-5 times more power is consumed. So replacing these bulbs with energy saving bulbs gives efficient energy lighting system. There are two main types of energy efficient devices:

1. CFL
2. LED (Light emmiting diode)

Tips for Energy saving in building:- 1. Smart Lights= A great deal of energy waste is due to carelessness.

Perhaps the most common needless energy expenditure is the failure of building users to turn off lights. Installing smart lights comes with upfront costs that are unavoidable, however, given the prevalence of light waste, they are likely to pay off in the long run.

2. Shade= Protecting your building from sunlight is a simple and relatively cheap energy saving solution. Installing shades or blinds keeps your building temperature down reducing the strain on your air conditioning system, and placing trees and landscaping in sun-facing areas can also help produce shade in the right spots. Another way to help keep your building cool without running up your HVAC bill is through window tinting.

3. Understand your building energy use profile= Knowing how your energy bill is racking up is the first step in reversing the trend. There are a host of tools for building owners to track energy usage. Which tools you elect to incorporate into the management of your property should be based on the amount of energy it consumes.

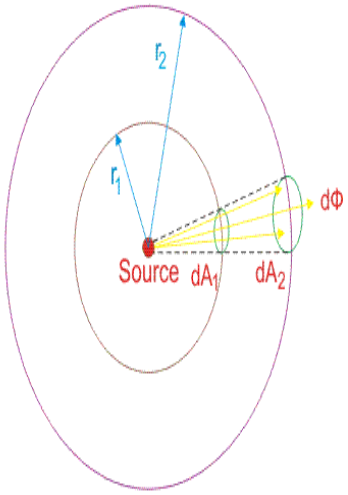
4. Stress the importance of good energy saving habits= Letting your employees and renters know the importance of efficient energy utilization can make an impact. Encouraging your renters and employees to do simple things like avoid obstructing HVAC vents with furniture or turning lights off when unused can go a long way. There's a fine line between respectfully communicating the importance of energy savings to your renters and being overbearing, but walking that line can create a better working environment for them and lower costs for you.

5. New commercial HVAC units= There is a good chance that your building is not equipped with an efficient HVAC system. Your HVAC system is likely accounts for over half of your building's net energy consumption. While getting a new HVAC system has upfront costs, in the long run, the amount you'll save will trump the cost of the system.

Laws of Illumination:- 1. Inverse square law of illuminance= This law states that the Illuminance (E) at any point on a plane perpendicular to the line joining the point and source is inversely proportional to the square of the distance between the source and plane.

$$E = \frac{I}{d^2}$$

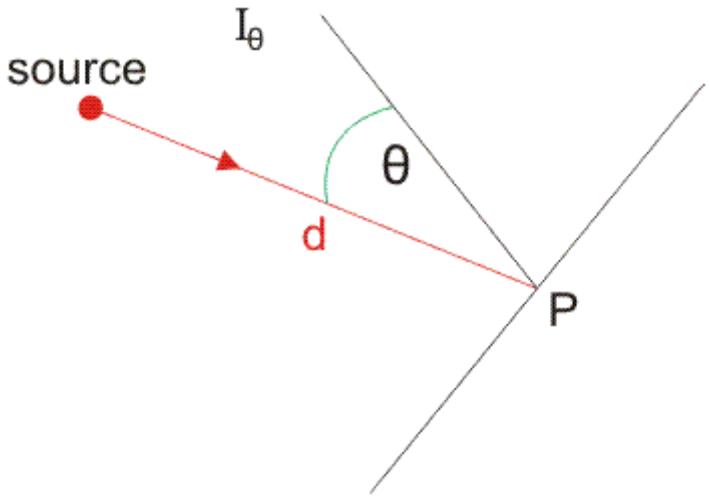
Where, I is the luminous intensity in a given direction.



2 Lamberts cosine law= The law states that Illuminance at a point on a plane is proportional to the cosine of the angle of light incident (the angle between the direction of the incident light and the normal to the plane).

$$E = \frac{I_\theta}{d^2} \cos\theta$$

It is the point source Illuminance equation. Where, I_θ is the luminous intensity of the source in the direction of the illuminated point, Θ is the angle between the normal to the plane containing the illuminated point and the line joining the source to the illuminated point, and d is the distance to the illuminated point.



Reqirements of proper lighting:- 1. Sufficiency

2. Distribution
3. Absence of glare
4. Absence of sharp shadows
5. Colour of light
6. Steadiness
7. Surroundings
8. Angle of light

Macro level approach at design stage:- The specific Energy Consumption is the measure of Energy Conservation activities in majority of Industries. The macro level approach for Energy Conservation is to

minimize the specific energy consumption. A three-pronged approach is suggested for Energy Conservation to minimize the specific energy consumption. High capacity utilization of equipment is very important in achieving low specific energy consumption. This brings down the fixed energy consumption and loss components such as lighting, Transformer loss etc. At-least 90% capacity utilization is to be ensured for achieving lower specific energy consumption. Achieving high capacity utilization is under the control of plant personnel. The Energy Efficient Plants are operating at 90 to 100 % of Capacity Utilization.

In industrial complexes, many induction motors may often run at no load or low partial load. Irrespective of the load conditions, these motors are, however, always connected to mains. Due to applied rated voltage at stator terminals, rated iron losses have to be supplied constantly to the motors. Summed up over years, these losses mean a waste of primary energy, whose availability on our planet is limited. If it were possible means of an additional switching device to reduce the terminal voltage of induction motors at no-load and low partial loads, some electrical energy might be saved.

CH-2-ENERGY CONSERVATION AND EC ACT 2001

Energy management:- **Energy management** includes planning and operation of energy production and energy consumption units. Objectives are resource conservation, climate protection and cost savings, while the users have permanent access to the energy they need. It is connected closely to environmental management, production management, logistics and other established business functions.

Energy management is the proactive, organized and systematic coordination of procurement, conversion, distribution and use of energy to meet the requirements, taking into account environmental and economic objectives.

Energy conservation:- **Energy conservation** is the effort made to reduce the consumption of energy by using less of an energy service. This can be achieved either by using energy more efficiently (using less energy for a constant service) or by reducing the amount of service used (for example, by driving less). Energy conservation is a part of the concept of Eco-sufficiency. Energy conservation reduces the need for energy services and can result in increased environmental quality, national security, personal financial security and higher savings. It is at the top of the sustainable energy hierarchy. It also lowers energy costs by preventing future resource depletion.

Energy can be conserved by reducing wastage and losses, improving efficiency through technological upgrades and improved operation and maintenance. On a global level energy use can also be reduced by the stabilization of population growth.

Energy can only be transformed from one form to other, such as heat energy to motive power in cars, or kinetic energy of water flow to electricity in hydroelectric power plants. However machines are required to transform energy from one form to other. The wear and friction of the components of these machine while running cause losses of very high amounts of energy and very high related costs. It is

possible to minimize these losses by adopting green engineering practices to improve life cycle of the components.

Energy efficiency:- Energy efficiency simply means using less energy to perform the same task – that is, eliminating energy waste. Energy efficiency brings a variety of benefits: reducing greenhouse gas emissions, reducing demand for energy imports, and lowering our costs on a household and economy-wide level. While renewable energy technologies also help accomplish these objectives, improving energy efficiency is the cheapest – and often the most immediate – way to reduce the use of fossil fuels. There are enormous opportunities for efficiency improvements in every sector of the economy, whether it is buildings, transportation, industry, or energy generation.

Need of energy efficiency:- 1. Reducing green house gas emmissions.

2 Reducing demand for energy imports.

3 Lowering our cost on a household and economy-wide level.

4 To increase the output.

5 To minimise the loses.

Energy conservation act 2001:- The Act empowers the Central Government and, in some instances, State Governments to: 1. specify energy consumption standards for notified equipment and appliances.

2. direct mandatory display of label on notified equipment and appliances.

3. prohibit manufacture, sale, purchase and import of notified equipment and appliances not conforming to energy consumption standards.

4. notify energy intensive industries, other establishments, and commercial buildings as designated consumers.

5. establish and prescribe energy consumption norms and standards for designated consumers.

6. prescribe energy conservation building codes for efficient use of energy and its conservation in new commercial buildings having a connected load of 500 kW or a contract demand of 600 kVA and above.

7. amend the energy conservation building codes prepared by the Central Government to suit regional and local climatic conditions.

8. direct every owners or occupier of a new commercial building or building complex being a designated consumer to comply with the provisions of energy conservation building codes.

9. direct, if considered necessary for efficient use of energy and its conservation, any designated consumer to get energy audit conducted by an accredited energy auditor in such manner and at such intervals of time as may be specified.

Energy conservation act 2010:- The new Energy Conservation (Amendment) Bill 2010, passed in this year Budget and Monsoon season under the Energy Conservation Act 2001, makes a stringent penalty for violating energy consumption norms. provided for setting up of an Appellate Tribunal for Energy Conservation, which would hear appeals against orders of the adjudicating officer, central or state government orders. The Amendment Act instead provides that the Appellate Tribunal for electricity established under the Electricity Act shall be the Appellate Tribunal for the purposes of Energy Conservation Act 2001.Greener buildings, a smarter electric grid, more efficient home appliances and more advanced industrial and manufacturing processes have the potential to significantly reduce India's electricity shortage, reduce pollution and decrease its emissions of greenhouse gases, while boosting the country's economic output over the next eight years.

Star Rating:- Star ratings are provided to all the major kind of appliances in the form of labels. These star ratings are given out of 5 and they provide a basic sense of how energy efficient each product is, just in a single glance. The manufacturers are officially required to put these labels as per **the Standards and Labelling Program introduced in 2006**.

The prime importance of these Star Ratings is to educate and inform consumers about how energy efficient each product is. This also makes the manufacturer responsible for creating products which are highly energy efficient as consumers may eventually prefer better rated products.

There are two variants of these labels, a big one and a smaller version:

Big label: The big energy rating label is aimed at appliances which have a constant usage and consume more electricity. These labels show additional information such as the yearly energy consumption of the product, brand name, product category and much more. For consumers, this big label is helpful as it allows you to calculate the actual money you would spend in electricity bills for that particular product.

Small label:- Small labels can be found in appliances which usually don't consume more energy. These labels just give you a visual representation of the energy consumption levels by showing star ratings.

Types of products available for star rating:- 1. Geysers

2Washing machines

3Air conditioners

4 TV

5 Freez

6 Computers

7 Ceiling fans

8 Tubelights, etc

CH-3- ENERGY AUDIT

Types and methodologies of energy audit:-

1. Priliminary audit
2. Detailed audit

Priliminary audit:- Preliminary audit is carried out in the limited time say within 10 days and it highlights the energy cost and wastages in the major equipment's and processes. It also gives the major energy supplies and demanding accounting. The questionnaire containing the industrial details of energy consumption process carried out, energy need to unit product; load data etc. must be completed before the pre-audit visit.

The pre-audit visit is done, by the audit team/audit consultant, in the plant area with the attention focused on the energy inputs, spots of wastage and available energy conservation opportunities. The items for waste recycling opportunities are identified. The data regarding energy inputs and outputs are collected for use during preliminary audit.

The preliminary audit spots energy waste spots and recommend short, intermediate and long term solutions. It should adopt step by step and cautious approach for improvements and new techniques of energy management and control system.

Detailed (comprehensive) energy audit:- Detailed energy audit, also known as comprehensive energy audit includes engineering recommendations and well defined projects with priorities. It account for the total energy utilised in plants. It involves detailed engineering for options to reduce energy consumption and also reduce cost. The duration of such studies is generally from 1 to 10 weeks. The action plan in divided into short term, medium term and long term actions.

The short term action plan requires no capital investment or least investment to avoid energy wastages and minimising non-essential energy uses and improving the system efficiency through improved maintenance programme.

The medium term action plan requires a little investment to achieve efficiency improvement through modifications of existing equipment's and other operations.

The long term action plan is aimed to achieve economy through latest energy saving techniques and innovations. The capital investments are required to be studied thoroughly while finalising the long term action-plan.

The comprehensive (detailed) energy audit is a thorough and extensive energy audit that analyses and quantifies the amount of energy consumption in each sub system of the plant and compares the same with the target energy consumption. Target per unit energy consumption is the optimum energy consumption per unit product.

Energy auditing reporting format:- This format includes following points:-

1. Executive summary
2. Background
3. Energy scenarios
4. Inventories
5. Baseline parameters and adjustments
6. System mapping details
7. List of potential energy saving projects
8. Detailed financial analysis
9. Details of approved projects
10. M&v plan
11. Risk assessment
12. Mitigation plan
13. Annexure

Energy audit instruments:- 1. Flue gas analyser

2 . Temperature indicators

3 . Infrared thermometers

4 . Thermal insulation scanner

5 . Stream trap monitor

6 . Conductivity monitor

7 . PH meter

8 . Thermohygrometer

9 . Ultrasonic flow meter

10 . U- Tube manometer

11 . Digital manometer

12 . Demand analyser

13 . Power analyser

14 . Lux meter

15 . Digital multimeter

CH-4-Electrical supply system and Motors

Types of Electrical supply system:- The supply of electric power to an electrical load is called power supply. The main function of the power supply is to convert electric current from a source to the correct voltage, current and frequency to power the load. Electrical outlet, energy storage device such as batteries, fuel cells, generator, solar power converters are generally known as power sources.

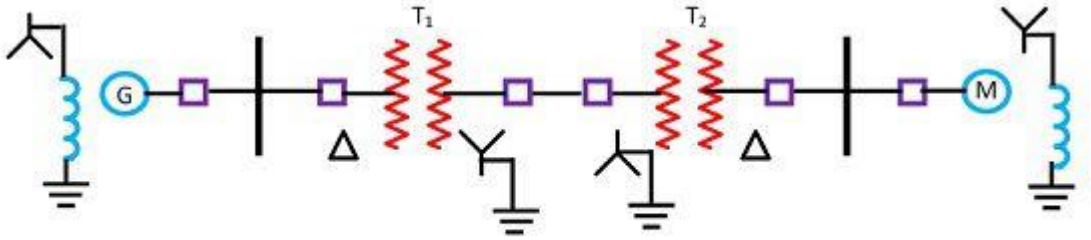
Power supply is classified into different categories:-

1. DC power supply = Such type of supply supplies a constant DC voltage to the loads. It may deliver from a DC source or an AC source.
2. AC-DC supply = AC energy can deliver DC power with the help of a rectifier, which converts the transformer output voltage to a varying DC voltage. The DC voltage passes through an electronic filter, which turns it into an unregulated DC voltage. There is also a register in series with the output to limit charging current and the final output power is fed to the load.
3. SMPS (Switched mode power supply) = The main input is converted to DC voltage via rectifier and filter and then switched on and off at a high frequency (10 KHz- 1 MHz) by an electronic switch. It has a safety feature to protect the device and the user.
4. Linear Regulator = Linear regulator converts a varying DC voltage to a constant. There is a current limiting function to protect the power supply and load from overcurrent. It is independent of fluctuation in input voltage and loads impedance to provide a steady value.
5. AC power supply = AC power supply can be taken from the main supply transferred to the desired voltage with the help of step up and step down transformer. This supply is divided into a single-phase and a three-phase system.
6. Programmable power supply = A PPS provides remote control operation through an analog input or digital interface such as RS 232. The controlled properties include voltage, current and frequency (in case of AC).

7. U.P.S = UPS has a feature to take power from two or more sources simultaneously. It is used as a backup supply as it takes over the load in dropout or failure condition of main supply. The process is so fast that the load never experiences an interruption.
8. High voltage power supply = HVPS supplies the bulk of energy, which is hundreds or thousands of volts for applications above 20KV. It includes voltage multiplier or high turns ratio, high voltage transformer or both to produce a high voltage.

Single line diagram:- Single line diagram is the representation of a power system using the simple symbol for each component. The single line diagram of a power system is the network which shows the main connections and arrangement of the system components along with their data (such as output rating, voltage, resistance and reactance, etc.).

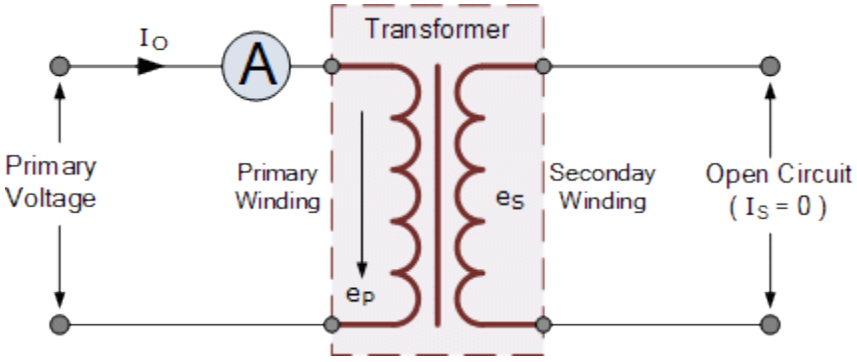
It is not necessary to show all the components of the system on a single line diagram, e.g., circuit breaker need not be shown in the load flow study but are the must for a protection study. In the single line diagram, the system component is usually drawn in the form of their symbols. Generator and transformer connections, star, delta and neutral earthing are indicated by symbols drawn by the side of the representation of these elements.



Single Line Representation of a Typical Power System

Circuit Globe

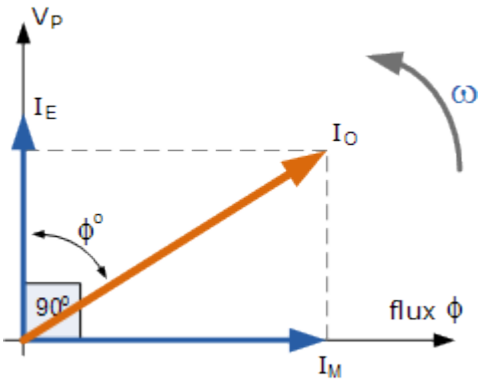
Transformer loading:- Transformers can provide a voltage on their secondary winding but to transfer electrical power between their input and output they need to be loaded.



A transformer is said to be on “no-load” when its secondary side winding is open circuited, in other words, nothing is attached and the transformer loading is zero. When an AC sinusoidal supply is connected to the primary winding of a transformer, a small current, I_{OPEN} will flow through the primary coil winding due to the presence of the primary supply voltage. With the secondary circuit open, nothing connected, a back EMF along with the primary winding resistance acts to limit the

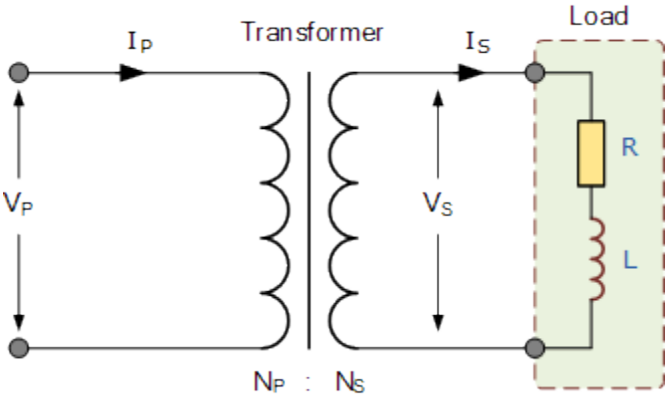
flow of this primary current. Obviously, this no-load primary current (Io) must be sufficient to maintain enough magnetic field to produce the required back emf.

Transformer No load condition = The ammeter above will indicate a small current flowing through the primary winding even though the secondary circuit is open circuited.



Io is very small compared to the transformers normal full-load current. Also due to the iron losses present in the core as well as a small amount of copper losses in the primary winding, Io does not lag behind the supply voltage, Vp by exactly 90°, (cosϕ = 0), there will be some small phase angle difference.

Transformer ON Load:- When an electrical load is connected to the secondary winding of a transformer and the transformer loading is therefore greater than zero, a current flows in the secondary winding and out to the load. This secondary current is due to the induced secondary voltage, set up by the magnetic flux created in the core from the primary current.



Tips for energy saving in transformer and Motors:- There are various tips for the saving of energy in transformer and motors, which are following:

1. Understand energy use

2. Measure

3. Fixed speed VS Variable speed

4. Turn it off

5. Efficient system design

6. Slow down

7. Use energy saving motor controls

8. Size motors correctly

9. Use high efficiency motors

10 Reduce wear and tear

Motor loading:- Most electric motors are designed to run at 50% to 100% of rated load. Maximum efficiency is usually near 75% of rated load. Thus, a 10-horsepower (hp) motor has an acceptable load range of 5 to 10 hp, peak efficiency is at 7.5 hp. A motor's efficiency tends to decrease dramatically below about 50% load. However, the range of good efficiency varies with individual motors and tends to extend over a broader range for larger motors. A motor is considered underloaded when it is in the range where efficiency drops significantly with decreasing load. power factor tends to drop off sooner, but less steeply than efficiency, as load decreases.

Overloaded motors can overheat and lose efficiency. Many motors are designed with a service factor that allows occasional overloading. Service factor is a multiplier that indicates how much a motor can be overloaded under ideal ambient conditions. For example, a 10-hp motor with a 1.15 service factor can handle an 11.5-hp load for short periods of time without incurring significant damage. Although many motors have service factors of 1.15, running the motor continuously above rated load reduces efficiency and motor life. Never operate overloaded when voltage is below nominal or when cooling is impaired by altitude, high ambient temperature, or dirty motor surfaces.

If your operation uses equipment with motors that operate for extended periods under 50% load, consider making modifications. Sometimes motors are oversized because they must accommodate peak conditions, such as when a pumping system must satisfy occasionally high demands. Options available

to meet variable loads include two-speed motors, adjustable speed drives, and load management strategies that maintain loads within an acceptable range.

Variation in efficiency and power factor with loading:-

Efficiency = (Output power) / (Output power + losses)

For a transformer running at full rated VA, the losses will be constant no matter what the load power factor.

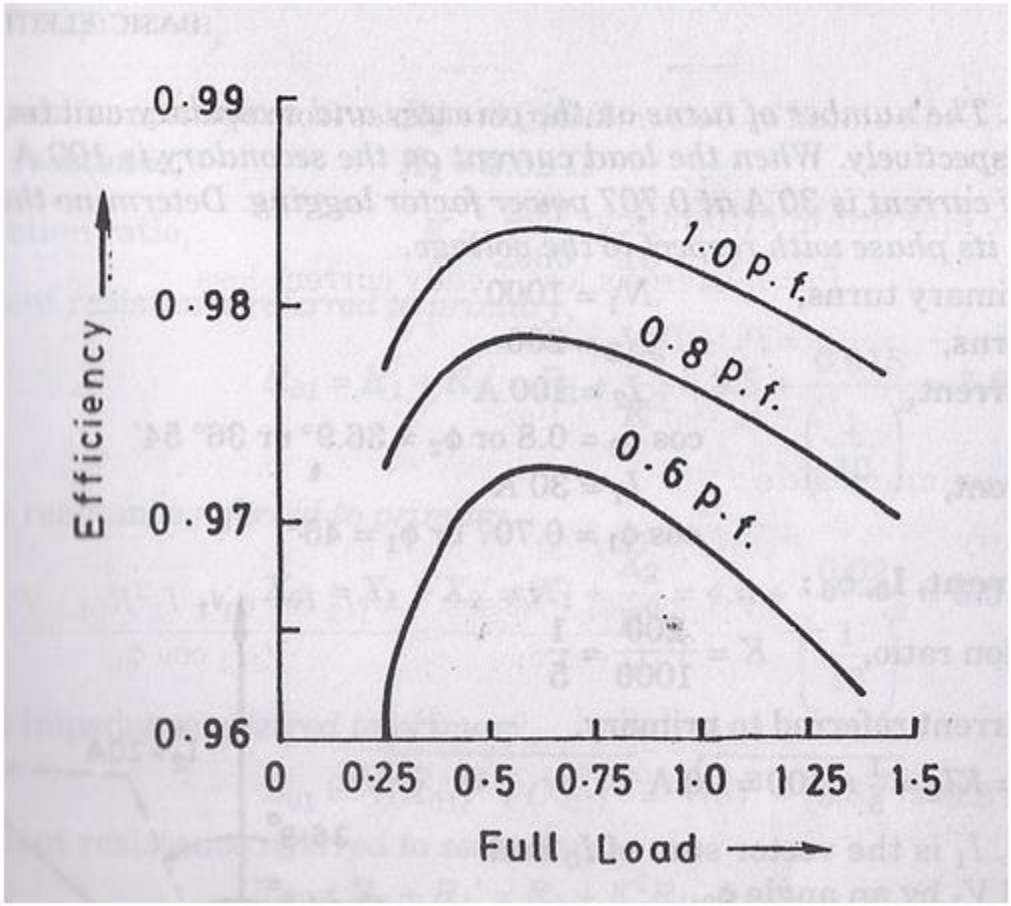
The (true) output power will be highly dependent on the power factor of the load.

If the load power factor is unity then output power will be maximised and the efficiency will be maximum.

If the load power factor is less than unity, the true or real output power will correspondingly reduce as will the efficiency.

In the extreme, if the load power factor is zero.

The graph between efficiency, power factor and loading is mentioned below:-



Need for energy efficient motors:- 1. It uses less electricity.

2. Robust in size.

3. cheap.

4. efficiency is very high.

5. Ease of use.

6. Simpler in design.

7. Noiseless operation.

8. Good power factor.

Initial cost VS life cycle cost:- The definition of life cycle cost is the sum of all recurring and one time (non-recurring) costs over the full lifespan, or over a specified period, of a good, service, structure, or system. It includes purchase price, installation cost, operating costs, maintenance and upgrade costs, and remaining (residual or salvage) value at the end of ownership or its useful life.

Definition of **Initial cost**= **Initial cost** means the moneys required for the capital construction or renovation of a major facility. **Initial cost** means, with respect to any Unit, the purchase price paid to the Company with respect to such Unit by the Member to whom such Unit was originally issued.

Cost analysis on life cycle basis:- **Life-cycle cost analysis (LCCA)** is a tool to determine the most cost-effective option among different competing alternatives to purchase, own, operate, maintain and, finally, dispose of an object or process, when each is equally appropriate to be implemented on technical grounds. For example, for a highway pavement, in addition to the initial construction cost, LCCA takes into account all the user costs, (e.g., reduced capacity at work zones), and agency costs related to future activities, including future periodic maintenance and rehabilitation. All the costs are usually discounted and total to a present-day value known as net present value (NPV). This example can be generalized on any type of material, product, or system.

In order to perform an LCCA scoping is critical - what aspects are to be included and what not? If the scope becomes too large the tool may become impractical to use and of limited ability to help in decision-making and consideration of alternatives, if the scope is too small then the results may be skewed by the choice of factors considered such that the output becomes unreliable or partisan. Usually, the LCCA term implies that environmental costs are not included, whereas the similar Whole-Life Costing, or just Life Cycle Analysis (LCA), generally has a broader scope, including environmental costs.

Various constructional features of EEM:- 1. Small in size.

2. Robust construction.

3. Efficient in operation.

4. cheap in cost.

5. rotor made up of copper bar conductors.

6. Speed is high.

7. Less noisy in operation.

EEM compared to standard motors:- Energy efficient motors are more reliable, durable, more efficient, robust in size, simpler in design, less noisy in operation, fast in operation, cheap in cost, require less maintenance as compared to standard motors, have good power factor and have more other advantageous features as compared to standard motors.

CH-5-Energy efficiency in electrical utilities

Understanding Electricity bill:-

Tariff Structure = The electric rate is the price you pay per unit of electricity to your energy utility or retailer. The electricity tariff (or rate) structure is the combination of rates, additional charges, and other rules that determine how your electricity bill is calculated.

Electrical energy produced by the power system is delivered to a large no customers. The tariff becomes the attention for the electric supply company. The company has to ensure that the tariff such that it not only recovers the total cost of producing electrical energy but also earns a profit on the capital investment.

1. Tariff structure means the type of tariff.
2. Each tariff structure has the different calculation to calculate the total energy which consumer to calculate the total energy charge which consumer has to pay for his consumption.
3. Electricity tariff can have various forms which vary from country to country as well as different markets of the same country.
4. Tariff scheme also differs according to consumer categories.

Consumers categories are:-

1. Residential
2. Commercial
3. Industrial
4. Agricultural

Different types of tariff are:-

1. Flat demand tariff
2. Simple tariff
3. Flat rate tariff
4. Step rate tariff
5. Block rate tariff
6. Two part tariff
7. Three part tariff

Components of power (KW,KVA,KVAR):- **Electrical power** contains two part, active **power** that is kilo volt amphere or inshort **KVA** and reactive **power** that is mentioned by **KVAR**. **Power** denotes by **KVA** when does not consider the **power factor** of load, if consider **power factor** of load then it describes as kilo **watts** or in short **KW**. Means **KW**= KVAxPower **factor**.

The power supplied by us is called apparent power (kVA). Apparent power is broken down into active power (kW), and reactive power (kVAR). Active power provides energy for motion, heat, light and sound.

Power factor:- It is defined as the cosine of the angle between voltage and current phasor. Or it is the ratio of the resistance to the impedance. It is a unitless quantity.

Sanctioned load:- **Sanctioned load** means the load in kW or kVA (kilo Watt or Kilo Volt Amp) which the Licensee has agreed to supply from time to time as per the governing terms and conditions and shall be subject to relevant orders of the Commission, as may be issued from time to time.

Maximum demand:- **Maximum demand** is the highest level of **electrical demand** monitored in a particular period usually for a month period.

Contract demand:- **Contract Demand** means the kW (or KVA) **demand** used to calculate the **Demand** Charge in each billing period. **Contract Demand** is always greater than or equal to the Maximum **Demand**.

Monthly minimum charges (MMC):- A monthly minimum indicates the minimum amount in fees that a processor will collect in any given month. If actual fees resulting from processing activity don't meet or exceed the minimum amount, the processor will charge however much is necessary to meet the minimum.

Pumps and its applications:- A **pump** is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: *direct lift*, *displacement*, and *gravity* pumps.

Pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work moving the fluid. Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power, come in many sizes, from microscopic for use in medical applications to large industrial pumps. Mechanical pumps serve in a wide range of applications such as pumping water from wells, aquarium filtering, pond filtering and aeration, in the car industry for water-cooling and fuel injection, in the energy industry for pumping oil and natural gas or for operating cooling towers and other components of heating, ventilation and air conditioning systems. In the medical industry, pumps are used for biochemical processes in developing and manufacturing medicine, and as artificial replacements for body parts, in particular the artificial heart and penile prosthesis.

Applications:- 1. Pumping water from the wells.

2. Aquarium and pond filtering.

3. Water cooling and fuel injection in automobiles.

4. Pumping oil or gas and operating cooling towers in energy industry.

5. They also have their **uses** in waste water recycling, pulp and paper, chemical industry etc.

Efficient pumping system operation:- This operation includes various methodologies described below= 1. Maintenance

2. Monitoring

3. Controls

4 Reduction of demands
5 Proper pump sizing
6 Multiple pumps for varying loads
7 Adjustable speed drives
8 Proper pipe sizing
9 Avoiding throttling valves
10 Replacement of belt drives
11 Improvement of sealing

Energy efficiency in agriculture pumps:- Objective of this program is to reduce the energy intensity of agriculture pumping sector by carrying out efficiency up gradation of agricultural pump sets. It is estimated that there are about 19 million pump sets and 2.5 lakh to 5 lakh new pump sets are being added every year. These pump sets are inefficient, largely because farmers have no incentive to invest in higher cost, higher efficiency pump sets due to low electricity tariffs for agricultural consumers.

Tips for energy saving in pumps:- 1. *Select the most efficient pump type for the application.*
2. *Right-size the pump*

3. *Trim the impeller*

4. *Minimize system pressure drop*

5. *Implement proper control valves*

6. *Implement variable speed drives (VSDs)*

7. *Maintain pumping systems effectively*

8. *Use higher efficiency/proper pump seals*

9. *Use multiple pumps*

10. *Eliminate unnecessary uses*

Types of air compressors:- The three most common air compressors are the reciprocating, rotary screw and centrifugal.

Reciprocating air compressors are considered positive displacement machines, which means they increase the pressure of the air by reducing its volume. Essentially, the machine takes in successive

volumes of air which is confined into a closed space and elevating the air to a high pressure. A piston within the cylinder helps accomplishes this feat. These types of air compressors are available as air-cooled or water-cooled in lubricated or non-lubricated configurations and are also provided in a number of different pressures and capacities.

Another type of air compressor is the rotary screw compressor which are positive displacement compressors. The most common rotary air compressor is the single stage helical or spiral lobe oil flooded screw air compressor. This type of air compressor consists of two rotors that are in a casing, and the rotors compress the air internally. These units are oil cooled, where the oil seals the internal clearances and have no valves.

Unlike the other two, the centrifugal air compressor is a dynamic compressor which is based on a transfer of energy from a rotating impeller to the air. This compressor is designed for higher capacity because flow through the compressor is continuous. Centrifugal air compressors are oil free and the oil lubricated running gear is separated from the air by shaft seals and atmospheric vents.

Air compressor applications:- 1. Painting vehicles in an auto body shop.

2. Sanding in an auto body shop or in woodworking.

3. Making snow at ski hills or for entertainment uses.

4. Using pneumatic nail guns for roofing.

5. Providing dental and medical services.

Leakage test:- A leak is a flow of gas (or liquid) through the wall of a vessel (via an imperfection such as a hole, crack or bad seal). Leaks require a pressure difference to generate the flow, they always flow from higher pressure to lower pressure.

Leaks are pictured as going from positive pressure (inside an object) to outside (at atmospheric pressure). This is not always the case (a leak could be from atmosphere to inside an evacuated object), but it helps to think about it this way because the units and terminology are based on this model.

Pressure / vacuum The test piece and the reference volume are simultaneously pressurised (or evacuated) to a preset pressure. The air in the system is then allowed to stabilise, with the supply valves all closed. The Differential Pressure Transducer is automatically zeroed. After this stabilisation time, the pressure change in the test piece is compared to the pressure change in the reference volume, using the Transducer. If the test piece is leaking, the difference will increase and be measured, an alarm limit may be set for a pass/fail decision.

Energy saving opportunities in compressors:- 1. Reduce leaks

2. Reduce the pressure

3. Optimize controls and maintenance

Energy conservation in HVAC system:- HVAC systems account for more than 50% of a facility's energy usage. After the cooling load has been reduced and the HVAC system has been optimised in terms of airflow, environmental controls and sensors, there still remain major areas of possible energy savings in the major components that form the basis of the system.

Most HVAC systems are designed to handle the maximum cooling or heating load required by the building. This maximum only occurs for a short period in the year and, for most of the time, the system is faced with a load below the maximum, and operates below full capacity. Operating below capacity generally means inefficient operation, and energy savings can be achieved by the use of systems that optimise operation under conditions below full capacity.

Energy conservation in refrigeration system:- 1. Use water-cooled condensers rather than air-cooled condensers.

2. Challenge the need for refrigeration, particularly, for old batch rocesses.

3. Avoid oversizing – match the connected load.

4. Consider gas-powered refrigeration equipment to minimize electrical demand charges.

5. Use free cooling to allow chiller shutdown in cold weather.

6. Use refrigerated water loads in series if possible. Convert firewater or other tanks to thermal storage.

7. Correct inappropriate brine or glycol concentration that adversely affects heat transfer and/or pumping energy. If it sweats, insulate it, but if it is corroding, replace it first.

Energy efficiency Ratio:- The **Energy Efficiency Ratio** (EER) of an HVAC cooling device is the **ratio** of output cooling **energy** (in BTU) to input electrical **energy** (in watts) at a given operating point. EER is normally calculated with a 95 °F outside temperature and an inside (return air) temperature of 80 °F and 50% relative humidity.

Types of fuels:- 1. Solid fuels

2. liquid fuels

3. gaseous fuels

4. Natural fuels

5. Artificial fuels

6. coal

7. oil

8. Natural gas

9. Nuclear fuels

Thermal Energy:- Thermal energy (also called **heat energy**) is produced when a **rise in temperature** causes **atoms and molecules to move faster** and collide with each other.

The energy that comes from the temperature of the heated substance is called thermal energy.

Thermal energy is energy that comes from a substance whose molecules and atoms are vibrating faster due to a rise in temperature.

The molecules and atoms that make up matter are moving all the time. When a substance heats up, the rise in temperature makes these particles move faster and bump into each other.

Energy contents in fuel:-

LPG Propane = 49.6MJ/KG

LPG Butane = 49.1

Gasoline (Petrol) = 46.4

Polypropylene plastic = 46.4

Butanol = 36.6

Coal (Anthracite) = 26, etc

Energy units:- Energy is defined as the work and its SI unit is joules.

Commercially it is measured in KWH (KILLO WATT HOUR)

MTOE (METRIC TONE OF OIL EQUIVALENT):- Millions of tonnes of oil equivalent (**Mtoe**) is a unit of energy used to describe the energy content of all fuels, typically on a very large scale. It is equal to 4.1868×10^{16} Joules, or 41.868 petajoules which is a tremendous amount of energy.

CH-6 General energy saving tips

Lighting system:- **Lighting** or **illumination** is the deliberate use of light to achieve practical or aesthetic effects. Lighting includes the use of both artificial light sources like lamps and light fixtures, as well as natural illumination by capturing daylight. Day lighting (using windows, skylights, or light shelves) is sometimes used as the main source of light during daytime in buildings. This can save energy in place of using artificial lighting, which represents a major component of energy consumption in buildings. Proper lighting can enhance task performance, improve the appearance of an area, or have positive psychological effects on occupants.

Lighting control systems reduce energy usage and cost by helping to provide light only when and where it is needed. Lighting control systems typically incorporate the use of time schedules, occupancy control, and photocell control (i.e.day light harvesting). Some systems also support demand response and will automatically dim or turn off lights to take advantage of utility incentives. Lighting control systems are sometimes incorporated into larger building automation systems.

Room air conditioners:- **Air conditioning** (often referred to as **AC**, **A/C**, or **air con**) is the process of removing heat and moisture from the interior of an occupied space to improve the comfort of occupants. Air conditioning can be used in both domestic and commercial environments. This process is most commonly used to achieve a more comfortable interior environment, typically for humans and other animals, however, air conditioning is also used to cool and dehumidify rooms filled with heat-producing electronic devices, such as computer servers, power amplifiers, and to display and store some delicate products, such as artwork. Air conditioners often use a fan to distribute the conditioned air to an occupied space such as a building or a car to improve thermal comfort and indoor air quality. Electric refrigerant-based AC units range from small units that can cool a small bedroom, which can be carried by a single adult, to massive units installed on the roof of office towers that can cool an entire building. The cooling is typically achieved through a refrigeration cycle, but sometimes evaporation or free cooling is used. Air conditioning systems can also be made based on desiccants (chemicals which remove moisture from the air).

Refrigerators:- It's working can be explained in following steps=

1. *Cool refrigerant is passed around food items kept inside the fridge.*
2. *Refrigerant absorbs heat from the food items.*
3. *Refrigerant transfers the absorbed heat to the relatively cooler surroundings outside.*

The working principle of a refrigerator (and refrigeration, in general) is very simple: it involves the removal of heat from one region and its deposition to another. When you pass a low-temperature liquid close to objects that you want to cool, heat from those objects is transferred to the liquid, which evaporates and takes away the heat in the process.

Different parts of refrigerator are = expansion valve, compressor, evaporator, condenser, refrigerant.

Water heater:- **Water heating** is a heat transfer process that uses an energy source to heat water above its initial temperature. Typical domestic uses of hot water include cooking, cleaning, bathing, and space heating. In industry, hot water and water heated to steam have many uses.

Domestically, water is traditionally heated in vessels known as *water heaters*, *kettles*, *cauldrons*, *pots*, or *coppers*. These metal vessels that heat a batch of water do not produce a continual supply of heated water at a preset temperature. Rarely, hot water occurs naturally, usually from natural hot springs. The temperature varies with the consumption rate, becoming cooler as flow increases.

Computers:- A **computer** is a machine that can be instructed to carry out sequences of arithmetic or logical operations automatically via computer programming. Modern computers have the ability to follow generalized sets of operations, called *programs.* These programs enable computers to perform an extremely wide range of tasks. A "complete" computer including the hardware, the operating system (main software), and peripheral equipment required and used for "full" operation can be referred to as a **computer system**. This term may as well be used for a group of computers that are connected and work together, in particular a computer network or computer cluster.

Fans:- It is defined as an apparatus with rotating blades that creates a current of air for cooling or ventilation.

Heaters:- An **electric heater** is an electrical device that converts an electric current into heat. The heating element inside every electric heater is an electrical resistor, and works on the principle of Joule heating, an electric current passing through a resistor will convert that electrical energy into heat energy. Most modern electric heating devices use nichrome wire as the active element, the heating element, depicted on the right, uses nichrome wire supported by ceramic insulators.

Blowers:- a machine for supplying air at a moderate pressure, as to supply forced drafts or supercharge and scavenge diesel engines.

Washing machines:- A **washing machine** (**laundry machine**, **clothes washer**, or **washer**) is a home appliance used to wash laundry. The term is mostly applied to machines that use water as opposed to dry cleaning (which uses alternative cleaning fluids and is performed by specialist businesses) or ultrasonic cleaners. The user adds laundry detergent, which is sold in liquid or powder form, to the wash water.

Water pumps:- A **water pump** is any device for moving water. The water pump is one of the oldest and most widespread machines, and exists in an enormous variety of styles.

Kitchens:- A **kitchen** is a room or part of a room used for cooking and food preparation in a dwelling or in a commercial establishment. A modern middle-class residential kitchen is typically equipped with a stove, a sink with hot and cold running water, a refrigerator, and worktops and kitchen cabinets arranged according to a modular design. Many households have a microwave oven, a dishwasher, and other electric appliances. The main functions of a kitchen are to store, prepare and cook food (and to complete related tasks such as dishwashing). The room or area may also be used for dining (or small meals such as breakfast), entertaining and laundry. The design and construction of kitchens is a huge market all over the world.

Transport:- **Transport** or **transportation** is the movement of humans, animals and goods from one location to another. In other words, the action of transport is defined as a particular movement of an organism or thing from a point A (a place in space) to a point B. Modes of transport include air, land (rail and road), water, cable, pipeline and space. The field can be divided

into infrastructure, vehicles and operations. Transport enables trade between people, which is essential for the development of civilizations.

CH-7-Energy conservation building code

Haryana ECBC and its features:- Haryana government has made implementation of Energy Conservation Building Code (ECBC) mandatory in stakeholder departments and different organisations.

These organizations are Architecture Department, Public Works (Building and Roads), Town and Country Department, Haryana Urban Development Authority, Housing Board, Police Housing Corporation, Urban Local Bodies Department and Municipal Corporations. Besides, an ECBC cell has also been created with support from Bureau of Energy Efficiency to assist stakeholders for the implementation of ECBC.

These regulatory steps include mandatory energy audit of the state government and other sector consumers, implementation of ECBC, LED lights installation and installation of solar rooftop power plants. The state government is committed towards energy conservation and energy efficiency and it has designated the Department of Renewable Energy as the designated agency to coordinate, regulate and enforce the provision of the Energy Conservation Act, 2001 in the state.

ECBC guidelines on building envelops:- The **Energy Conservation Building Code** (**ECBC**), was launched by Ministry of Power, Government of India in May 2007, as a first step towards promoting energy efficiency in the building sector. The ECBC was developed by an Expert Committee, set up by India's Bureau of Energy Efficiency, with support and guidance from United States Agency for International Development (USAID) and significant inputs from various other stakeholders such as practicing architects, consultants, educational institutions and other government organizations.

The successful implementation of the code requires development of compliance procedures (compliance forms and development of field-test compliance forms and procedures), in addition to building capacity of architects/designers/builders/contractors and government official in States and Urban and Local Bodies (ULBs). It is also dependent on availability of materials and equipment that meet or exceed performance specifications specified in ECBC.

ECBC guidelines on heating,ventilating and air conditioning:- Heating, ventilation and air conditioning accounts for a significant portion of a commercial buildings energy use and represents an opportunity for considerable energy savings. This tip sheet act as a primer on energy efficient HVAC systems and proven technologies and design concepts which can be used to comply with the HVAC provisions in energy conservation building code. ECBC includes provisions for most HVAC system types.

The code contains mandatory requirements for the following elements of HVAC system:

1. Natural ventilation
2. Equipment efficiency
3. Controls
4. Piping and ductwork
5. Condensors
6. System balancing
7. Economiser

8. Hydronic system

ECBC guidelines on lighting:- The lighting requirement in the code apply to:

1. Interior space of building.
2. Exterior building features, including facades, illuminated roofs, architectural features, entrances exits, loading docks and illuminated canopies.
3. Exterior building grounds lighting that is provided through the building's electrical service.
4. Lighting in dwelling units.

ECBC guidelines on electrical power:- Mandatory requirements of the code , cover the following electrical equipments and system of building:

1. Transformers
2. Energy efficient motors
3. Power factor correction
4. Electrical metering and monitoring
5. Power distribution systems

ECBC guidelines on Star labeling:- BEE has introduced the **star labelling** programme for existing commercial buildings, which provides **label** to the buildings based on their actual energy performance. The BEE **star labelling** is applicable to buildings with the connected load of 100 kW or greater or contract demand of 120 kVA or greater.