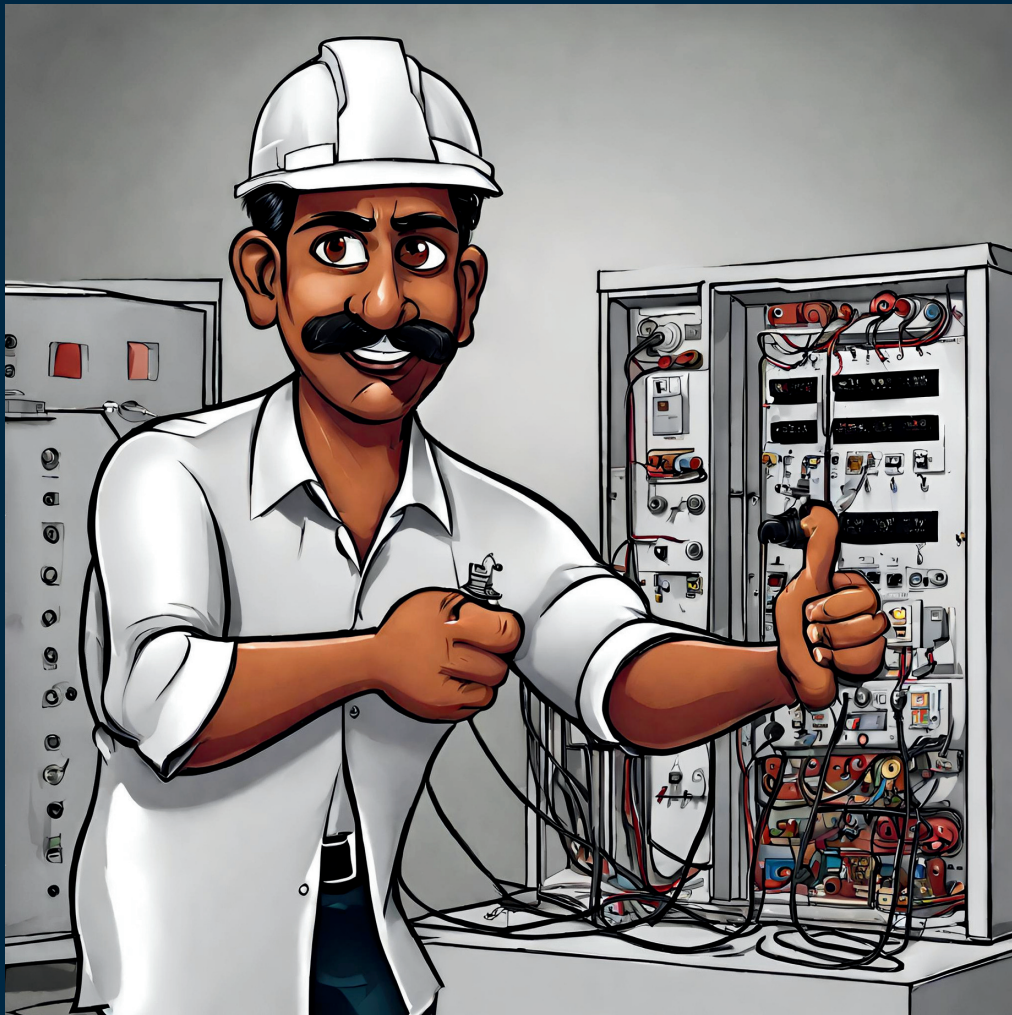


Creating a Sustainable Home

A HANDY MANUAL FOR ELECTRICIANS



CAG

Citizen consumer and civic Action Group

Creating a Sustainable Home
A HANDY MANUAL FOR ELECTRICIANS

Creating a Sustainable Home: A HANDY MANUAL FOR ELECTRICIANS

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About CAG

CAG is a thirty eight year old non-profit, non-political and professional organisation that works towards protecting citizens' rights in consumer and environmental issues and promoting good governance processes including transparency, accountability and participatory decision-making.

Preface

In this technologically advanced world, electricity is increasingly the primary source of energy, often taking over tasks that were typically done through alternate energy sources. As an example, many families now use an electric rice cooker, representing a shift from gas based cooking. The increasing popularity and demand for Electric Vehicles (EVs) is another case in point. Of course, electrical appliances for space cooling, refrigeration and communication - mobile phones - have become ubiquitous.

Households tend to have sparse knowledge of how interconnected electricity systems are in their homes. There are a myriad wires, electrical layouts, and plugs that power these equipment. They play a vital role in ensuring that the appliances run “safely” without any trouble. The word “safely” is emphasised to highlight the risk of electricity related accidents that can occur due to sub-standard wiring, poor understanding of earthing or the need to protect the home from lightning strikes etc.

Further, placement of household appliances play an important role in helping them to not only save electricity but also create an accident-free environment. For example, lights placed in a far corner of the room will not necessarily help the members of the house to get optimal benefit for reading etc while dark corners and shadows may create accident prone zones.

This brings us to an important point. Residents should choose appliances where its usage can be enhanced while reducing its electricity consumption. Of course, this has a knock-on effect on increase or reduction of electricity bills. While consumers may have an awareness of energy efficient lighting such as LED bulbs, they may not know that other interconnected aspects such as wiring, plugs, placement of appliances etc.

Now we come to the role of the electrician. They are best placed to inform and advice residents on the above points. It is necessary that electricians view the house holistically and provide a balanced advice to residents. They must do it in the best possible way to get both maximum safety and efficiency from their appliance.

Electricians must engage in discussion with the residents to understand their need and requirement. For example, residents may require a well-lit home as a choice while taking cost effectiveness, energy efficiency and safety into consideration. The electrician, on his part, may need to take into account a) the layout of the house, b) understand placement of appliances and fixtures for maximum lighting effect, c)

ensuring energy efficient lighting, d) focus on safety - wires, plugs etc. The residents may also ask for technologically advanced solutions or “Internet of Things (IoT)” for getting accurate consumption data and remote monitoring and control of appliances. It is important that electricians have a fair understand of IoT to be able to proper advice.

The handbook has also chapters on rooftop solar and electric vehicles (EVs). These electrical equipment are increasingly becoming part and parcel of our homes.

Taking the case of solar energy systems, awareness surrounding its usage - heating and electricity - will help residents take decisions. It is important to consider process of procurement, installation and maintenance. For EVs, knowledge of the technology, residents should consider its advantages and disadvantages, setting up of a charging infrastructure for homes, and maintenance.

To conclude, we encourage residents and electricians to have productive conversations about energy efficiency and conservation. They should keep in mind the safety and security while transitioning to resilient, green, and sustainable homes.

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Chapter 1

Energy conservation and energy efficiency

ENERGY CONSERVATION

The term "energy conservation" refers to minimising energy consumption by *using less of it without compromising comfort, quality or output*. This could take the form of utilising fewer energy services or utilising energy-efficient devices like LED (Light Emitting Diode) lights, Smart Thermostats, Energy Star appliances, etc. or adjusting the settings for example, increasing the temperature setting of air conditioners.

It is practised by changing our usage and behavioural patterns. Conservation doesn't mean making the resources last longer, but reducing their demand and enabling them to replenish. Switching to a different source of electricity (for example renewable sources like solar energy) is one wise method to go about it.

There can be countless examples of energy conservation. These include turning off lights when leaving a room, unplugging equipment or appliances when not in use, and cycling rather than driving whenever possible.

ENERGY EFFICIENCY

Energy efficiency refers to producing the same output with *lower energy consumption*.

For example, an incandescent bulb requires 60 watts of energy to produce 800 lumens of light. The same 800 lumens of light can be made using 8 watts of LED bulbs. So energy efficiency leads to energy conservation.

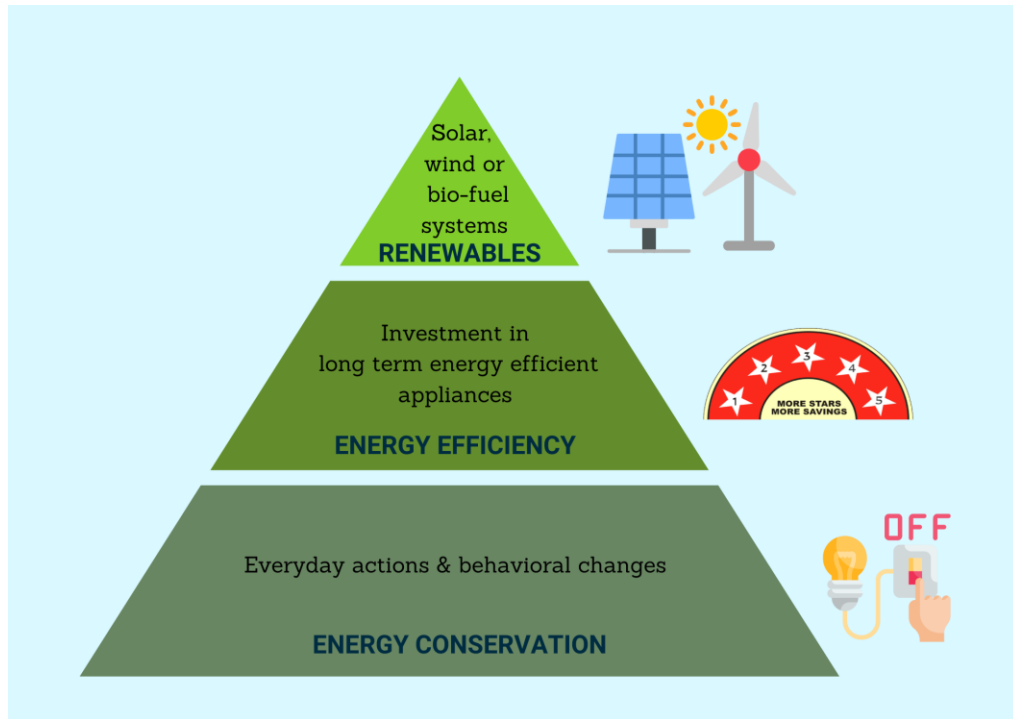


Fig 1:The EnergyPyramid | Image based on [SCAG](#)

IMPORTANCE OF ENERGY CONSERVATION AND ENERGY EFFICIENCY

i. Environmental benefits

India is still dependent on fossil fuel (coal, lignite, gas, and diesel) based thermal energy for 62% of its electricity needs (Source: Ministry of Power, Govt. of India). Overmining these fuels leads to natural resource depletion, which comes with the accumulation of enormous amounts of waste, impacting our lives. Also, mining and processing these fossil fuels are expensive and affect natural ecological systems. Thermal power plants pollute the air, soil, and water contributing significantly to climate change. Hence, every unit saved will ensure that one unit of power generated by a thermal plant is reduced. This will result in reducing environmental degradation, thus saving our planet from global warming and various climate risks in the long run.

ii. Social and financial benefits

LEDs and CFLs compared to traditional bulbs help save electricity. This is multiplied manifold on switching to renewables like solar heaters, solar cookers, electrical vehicles etc. Governments are promoting these appliances by providing them at subsidized rates, resulting in a win-win situation.

Energy conservation and its efficient use, by favouring reduced energy consumption, can contribute to energy security ie. less dependency on other countries. It is to be noted that more than 85% of petroleum products are imported as we have very little oil resources.

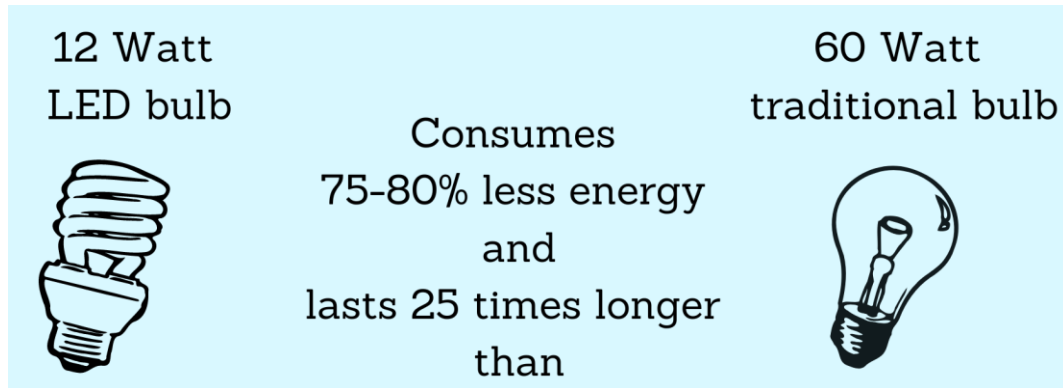


Fig 2: Traditional vs LED bulb energy consumption | Data source: [Energy](#)

iii. Health benefits

Energy efficiency measures can contribute towards good physical and mental health primarily by creating sustainable indoor living environments with ideal temperatures, humidity levels, noise levels, and improved air quality. This, in turn, promotes health and thus longer lifespans for users.

For example, on hot days, overcooling can impact health in many ways. Maintaining too low an indoor temperature can lead to cold-related illnesses, respiratory issues, decreased immune function and musculoskeletal discomfort. It can also impact mental well-being and reduce circulation. It is important to maintain a comfortable temperature range and ensure adequate insulation and heating to mitigate these health risks.

iv. Reduced energy cost

Energy-efficient buildings consume less energy compared to conventional buildings, saving fair amounts for domestic consumers and small businesses, and creating a notable difference for large companies.

Lower energy cost in turn brings down the overall cost of energy paid by consumers, thus promoting affordable energy.

v. Enhanced work productivity

Energy-efficient buildings are designed to provide optimal indoor environmental quality, including temperature control, ventilation, and lighting. A comfortable working environment with proper temperature and lighting levels can enhance employee well-being, reduce fatigue, and improve concentration and productivity.

vi. Equitable access to energy technologies in the future

Widespread usage of energy-efficient appliances and adoption of green/resilient buildings will reduce their price in the future thus making them affordable for poorer families.

WAYS TO CONSERVE ENERGY

Energy conservation does not need any extra investment. The best way to start saving on your electricity costs is to get smart with how you use electricity. It has everything to do with your daily habits and requires only a little extra effort. It starts with the design or construction of your home.

- **Location:** The building's location is an essential factor that contributes to the utilization of passive solar energy to reduce heat gain in the summer and loss in the winter. In the summer, the midday sun is at a high angle whereas, in winter, it is at a low angle. Careful decisions on the home's HVAC (Heating, Ventilating and Air Conditioning) almost halve electricity expenses. Houses facing north-south direction receive more sunshine towards the back of the house. During hot afternoons, homes in the north should have shade in their backyards. In colder climates, windows should be positioned to allow large amounts of sunlight in. South-facing residences capture sunlight in the winter but block it in the summer. For example, 'passive building' refers to constructing your house in a way that minimises energy usage and promotes energy efficiency and conservation.

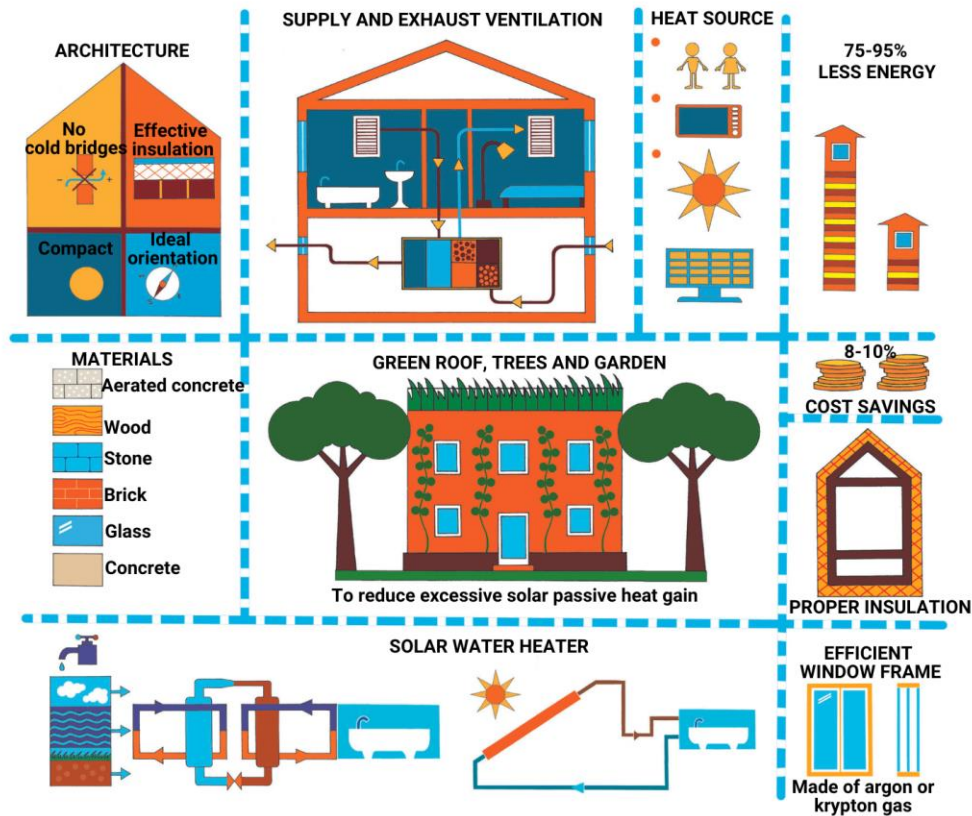


Fig 3: Passive Housing | Source: [Jupps](#)

- Suitable design:** A well-designed ventilation system for an energy-efficient house provides comfort and saves energy consumption by preventing the overuse of electrical equipment used for heating and cooling purposes. Properly designed windows and doors can be strategically placed to allow cross-ventilation, where cool air enters through one opening while warm air exits through another. It is important to consider the orientation and placement of windows to optimize airflow.
- Roofing material:** The roofing materials chosen will impact overall energy efficiency. The roof's material can help save energy, reduce air pollution and greenhouse gas emissions, while also keeping the house cool without air conditioning.

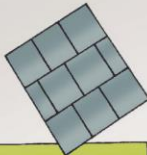


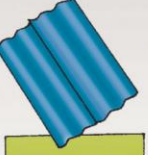
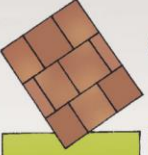
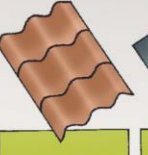
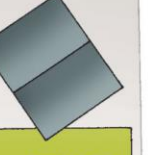














						
CLAY TILE	SLATE TILE	CONCRETE TILE	METAL	WOOD	SPANISH TILE	ASPHALT SHINGLE
						
<ul style="list-style-type: none"> • Attractive • Long lasting • Low maintenance • Colour varieties • Non combustible 	<ul style="list-style-type: none"> • Aesthetic • Long lasting • Low maintenance • Fireproof 	<ul style="list-style-type: none"> • Durable • Relatively light weight • Low maintenance • Variety 	<ul style="list-style-type: none"> • Durable • Fireproof • Low maintenance • Low weight • Variety • Recyclable • Can be installed over existing roof 	<ul style="list-style-type: none"> • Natural look • Easy repair and replacement • Long lasting 	<ul style="list-style-type: none"> • Aesthetic • Long lasting • Low maintenance • Non combustible • Great insulator 	<ul style="list-style-type: none"> • Low cost • Easy installation • Colour varieties • Easy to repair • Fireproof
						
<ul style="list-style-type: none"> • Heavy • Some colours may fade • Expensive • Complex installation • Non combustible 	<ul style="list-style-type: none"> • Expensive • Heavy 	<ul style="list-style-type: none"> • Expensive 	<ul style="list-style-type: none"> • High initial cost • Difficult installation • May need periodic painting 	<ul style="list-style-type: none"> • Complex installation • High maintenance • Low durability • Fire hazard 	<ul style="list-style-type: none"> • Expensive • Heavy 	<ul style="list-style-type: none"> • Short life expectancy • High maintenance • Not ecofriendly

Fig 4: Roofing materials and their use | Source Unknown

- **Water conservation system:** An increasing number of energy-efficient houses are incorporating water-saving systems, for instance, greywater recycling systems. Greywater is wastewater from showers, sinks, laundry tubs, and washing machines. Installation of a diversion system carries the greywater from a washing machine to the bathroom or garden. Using the wastewater from water purifiers for purposes of cleaning, bathing, etc also helps in saving water which in turn helps in saving energy.

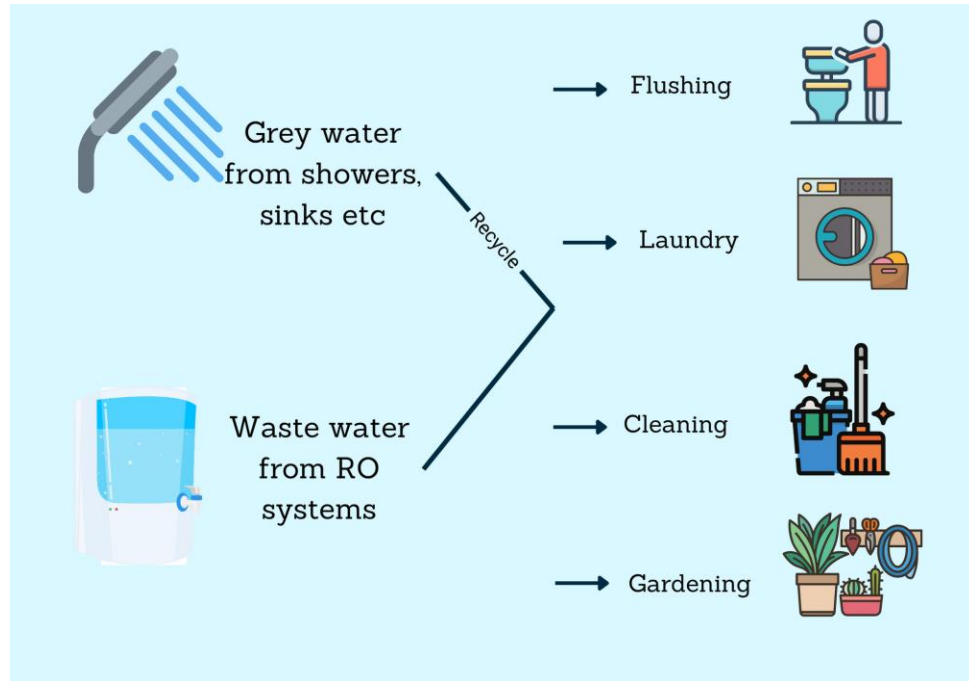


Fig 5: Reusing recycled grey water and waste water from RO systems

- Habitual changes:** When not in use, turn off TVs, lights, fans, devices, gadgets, and even fixtures like water heaters. Keep the lights in the room turned on only when they are needed, and unplug any electrical equipment that isn't in use. Electrical equipment uses energy even when plugged in but not in use. So unplug all devices after use.

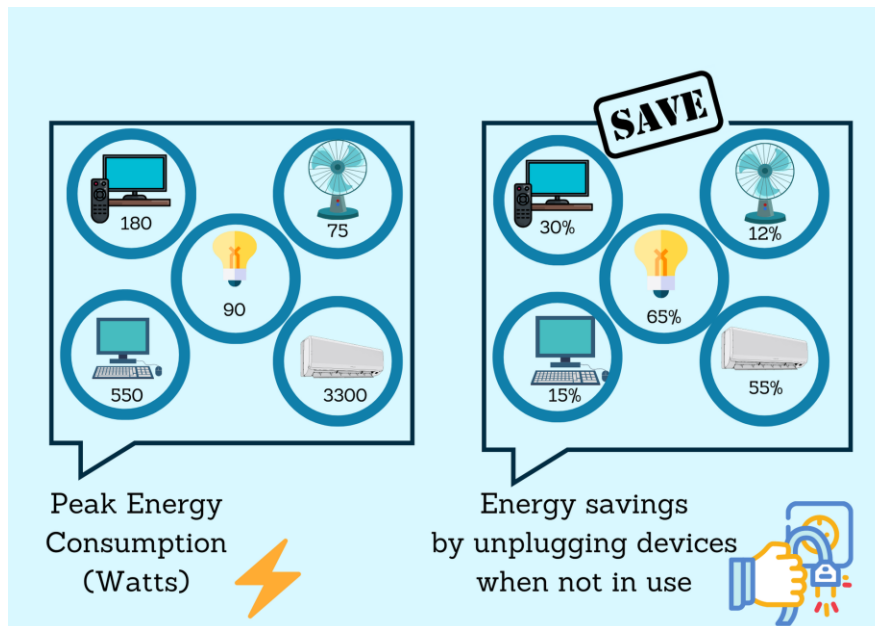


Fig 6: Five common devices' peak energy consumption and energy savings when unplugged

- **Introducing energy saving devices:** Using LEDs, CFLs, star labelled appliances, switching to solar equipment, and electric vehicles (EVs) are smart and easy ways to save energy consumption. BLDC fans are now available in the market which consume only 50% of the power required for conventional fans.

Chapter 2

Consultation with mason and consumers

Introduction

Building orientation is the process of designing a structure so that it receives maximum ventilation (or air circulation) and natural light in all weather conditions. It provides a comfortable living environment while also saving money on energy bills. The orientation of a building can protect against the negative effects of bad weather. When planning to construct the house, it should be ensured that the architect designs the structure in such a way that energy loss is minimized.

Natural energy gains include passive solar heating (collecting heat from the sun and retaining it in heat-storing materials), passive solar cooling, natural ventilation flow, and daylight. These can be maximized by utilizing the site's and its surroundings' potential contribution to a building's performance by implementing:

- A building layout that places functions in locations that reduce the need for the application of energy;
- A layout that considers the potential advantages of solar gains, while lowering the likelihood of glare and overheating;
- A shape that encourages the use of natural light and ventilation, as well as minimizes heat loss,
- Natural ventilation whenever possible and appropriate, with mechanical ventilation and/or air conditioning used only when necessary.

Considerations before building design

- **Energy efficiency measures for building construction**

These include approaches to designing a home through which minimum energy consumption while maintaining and enhancing the comfort of living in the house can be achieved. These measures fall into the following categories:

- **Reducing heating demand:**

- *By limiting the exposed surface area of the building* - The amount of space exposed to the outdoors through exterior walls and ceilings is determined by the shape of the building. Keep this exposed area

to a bare minimum to save energy. A simple square or rectangular floor plan is the most cost-effective to build and for space heating and cooling. When a house has a complex shape, it increases the exposed surface area as well as construction and energy costs.

- *Improving the fabric of the building's insulation* - Conduction (heat transfer from the hot part to the cold part) accounts for the remaining two-thirds of heat loss through foundations, floors, walls, ceilings, roofs, windows, and doors. High levels of insulation in the sidewalls, basement walls, and doors can reduce heat flow in and out of the building due to conduction. The U-value (or value of heat lost) for windows should be as low as possible.
- *Reducing the amount of air that escapes through the vents* - Air leaks tend to reduce a house's energy efficiency. The loss of energy through these leakages can be reduced by caulking (filling) holes or cracks inside the wall surface, walls, door or windows, sealing the pipes or ducts that penetrate the exterior wall.
- *Opting for energy-efficient heating and cooling systems with reliable controls.*

- **Reducing cooling demand:**

Energy consumption in typical air-conditioned homes or buildings is approximately double than that achieved through natural ventilation. The need or size of ACs can be reduced by proper utilization of solar gains via glazing (fitting glass window panes). The section below gives an in-depth understanding of the types of glasses and their suitability.

Types of glass, their pros and cons

Glass type	Definition	Pros	Cons
Annealed Glass	A basic clear glass used for windows and doors.	Pocket-friendly. Strong against wind and heat changes. Full light transmission.	Breaks into big inconsistent shapes. Can be used in a limited size, due to its strength.

		Clear visibility. Available in opaque and different tones.	
Toughened Glass	This is annealed glass which undergoes heating and cooling to extend its durability. Commonly used for safety purposes or for large panel glass in bathrooms and elevation windows.	Heat-resistant, strong, and safe. Shatters into small pieces rather than large shards when broken, thus safer than annealed glass. Stronger than regular glass, both physically and thermally. Various opaque tones are available.	Once installed, it cannot be recut. If you want toughened glass for a sliding door and then decide to install a pet door later, the entire panel will need to be replaced.
Frosted Glass	Commonly used as bathroom glasses or to improve natural light in the room.	Increased privacy. Better diffusion of light. Easy to clean. Better replacement for blinds or curtains for windows.	Can be made of annealed or toughened type of glass. Disadvantages will be the same as that type of the glass chosen.
Laminated Glass	Made up of more than two sheets of glass, and is classified as a safety glass.	Pocket-friendly. Better security. Less fragile. Higher resistance to UV rays Sound insulation	In an emergency, it can be difficult to break. When exposed to water for an extended period of time, the interlayer can be compromised.
Tinted	Colored (mostly	Reduces the fading	Reduces visible light.

Glass	blue, green, and gray) glass.	of furniture caused by UV rays. During the day, maximizes privacy while minimizing heat and glare.	Reduces visibility.
Mirrored Glass	It's made of reflective glass and has a mirror effect.	Reflects light, making it ideal for creating the illusion of space in small spaces.	Can damage the wall when taken off.
Low E Glass	Glass with a low emissivity. It has a microscopic, transparent metallic coating that reduces heat and cold transfer through the glass, making a home more energy efficient.	Reduces energy usage. Increases insulation when used with laminated and double-glazing glass.	In some lights/angles, the image may appear blurry.
Double Glazing	Two-layered glass with a gap in between reducing the rate of heat transfer through the glass and thermal conductivity.	Reduces energy costs. Minimized condensation(vapour to liquid change). Reduced noise. Superior insulating properties.	Expensive.

Tempered Glass	It has been processed to add both internal and external stress to the material. The tensile tension in the body counteracts the compressive surface stress of tempered glass.	Compared to regular glass, tempered glass is more durable both mechanically and thermally. Flexible to be shaped in different forms and styles 3-7 times stronger than annealed glass	Needs to be cut, drilled and polished before tempering Vulnerable to damage around the edges Can break when exposed to extreme conditions.
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Passive strategies

This involves making use of natural environmental conditions in order to keep buildings comfortable without relying on purchased energy.

Passive strategies are built into a building's design to work with the site's natural elements (such as sun and wind patterns) to provide natural heating and cooling of spaces throughout the year.

- **Building Envelope**

The exterior walls, windows, doors, roof, skylights, and other features of a home make up the "building envelope." It serves as the exterior of a home and aids in the protection of everything inside. The type of building envelope one selects will determine how comfortable it remains throughout the day, night, and year. This is because a well-designed building envelope keeps a home warm, cool, or lit as might be needed for longer, reducing the need for heaters, air conditioners, and indoor lighting.

Understanding how heat moves, will help us understand how the building envelope of our homes will work. Heat is transferred from a warm to a cool environment. If a building envelope isn't designed properly, heat will leak out.

Flow of heat, in and out of the building is quicker if:

- There exists a large temperature difference between the outdoor and indoor,
- A larger part of the roof and wall area is exposed to outside, and

- The roof, wall and floor materials are good conductors of heat.

Several low-cost passive design methods are described below that can be incorporated into the design of a home to reduce electricity consumption and increase comfort.

- **Orientation**

A home's orientation is the direction it faces. Homes that are oriented toward gardens, and green spaces prove energy-friendly. The desire for comfort can sometimes dictate how rooms are laid out, where windows are placed, and how spaces are used.

An energy-efficient building envelope can help you achieve naturally lit, ventilated, and comfortable rooms throughout the year.

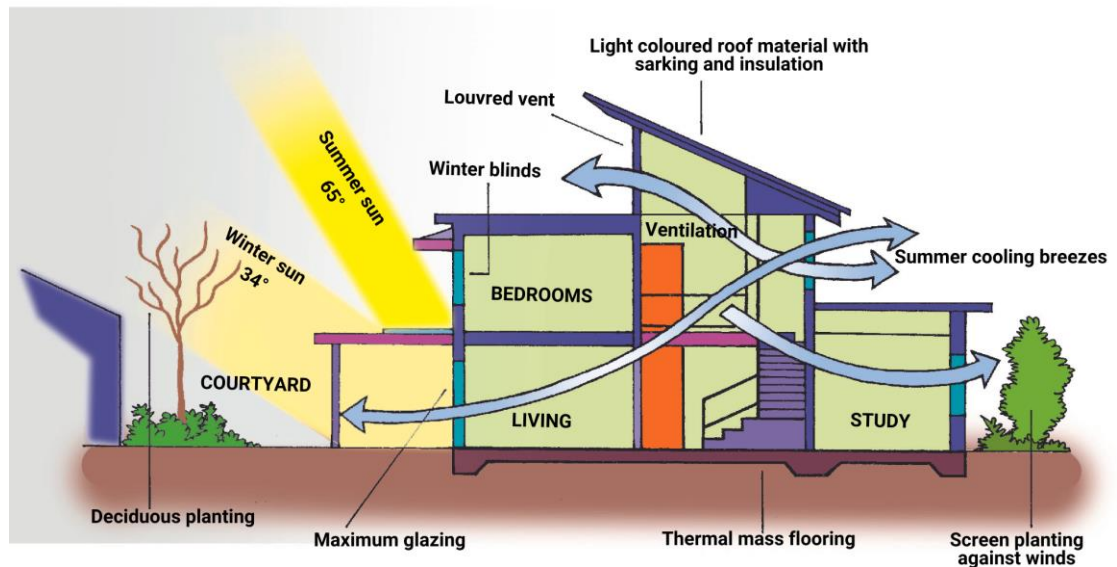


Fig 7: Building orientation and heat flow into the building | Source: [Inhabitat](https://www.inhabitat.com)

How to choose the right orientation for homes in hot climates?

For the building

In order to act as a thermal barrier, non-habitat rooms should be placed on the exterior facades of buildings in this climate zone. Buildings' longer walls should face North and South to receive the least amount of solar exposure.

To prevent the passage of hot air and odour from the kitchen, the kitchen should ideally be situated on the leeward side of the structure.

For Windows and Openings

Since light coming from the north is constantly dispersed and indirect, windows and big openings in walls with thick shutters should be fixed on the northern and western faces. Additionally, the entrance on the west side allows the breeze to enter. (In mist locations, breeze penetrates most locations from the west) Windows should make up 15–20% of the floor area.

For Walls

When it comes to a building's ability to retain heat, wall thickness is crucial. It is preferable to have thicker exterior walls since these act as an insulating barrier. A significant impact is also played by exterior wall painting. The exterior surfaces of walls painted in bright colours have strong reflectivity and do not absorb heat. Walls should have a smooth, non-dust-attracting surface. Cavity walls and walls made of hollow bricks or blocks can also be installed since they offer excellent thermal insulation.

For Roof Insulation

Roofs should be constructed with high-quality insulation that is sloped windward, reflects radiation, and does not absorb heat. False ceilings can be utilised to enhance a building's thermal performance. A flat roof should have terracing in the form of burnt clay block paving, lime concrete, foamed concrete, or mud phuska over the slab. Whitewashing or other reflective paint should be used to make the top of the roof reflective to reduce the heat penetration inside the building.

How to choose an orientation for homes in cold climates?

For the building

To maximise heat gain, buildings are constructed on the south slope. A building site offering natural wind barriers must be chosen. Orienting the building on the leeward (opposite to the direction of wind flow) side minimises the building's exposure to cold winds. In case the southern side happens to be the leeward side, glazing of windows can be utilized to allow minimum wind entrance.

For Windows

Windows should be facing towards the south to ensure direct gain. Also, compact construction implies lower heat losses from the building.

For Walls

Walls can be made up of materials that lose heat slowly. Walls facing the south can be of high thermal capacity to capture heat from the daytime to be used later. Walls can be insulated to avoid condensation (using two coats of bitumen, 300-600 gauge polyethene sheet or aluminium foil) on the warm side.

- **Shading**

A house is shielded from direct sunlight and rain by shades. Shades are temporary or permanent structures that protect your home from direct sunlight and rain by forming horizontal or vertical projections around the window. A verandah or a projected roof can also provide shade. Proper shading in the house significantly reduces energy consumption.

External Shading Devices

A fin is a vertical projection on the window sides, whereas an overhang is a horizontal projection above the window. Both shades are designed to keep direct sunlight out of your windows. These features must be planned carefully, taking into account the time of year and the hours of the day when shading is required for your home. For instance, windows facing north require minimal shading due to low sunlight received in the major part of the year. Places with colder climatic conditions can be unshaded to allow maximum sunlight to enter.

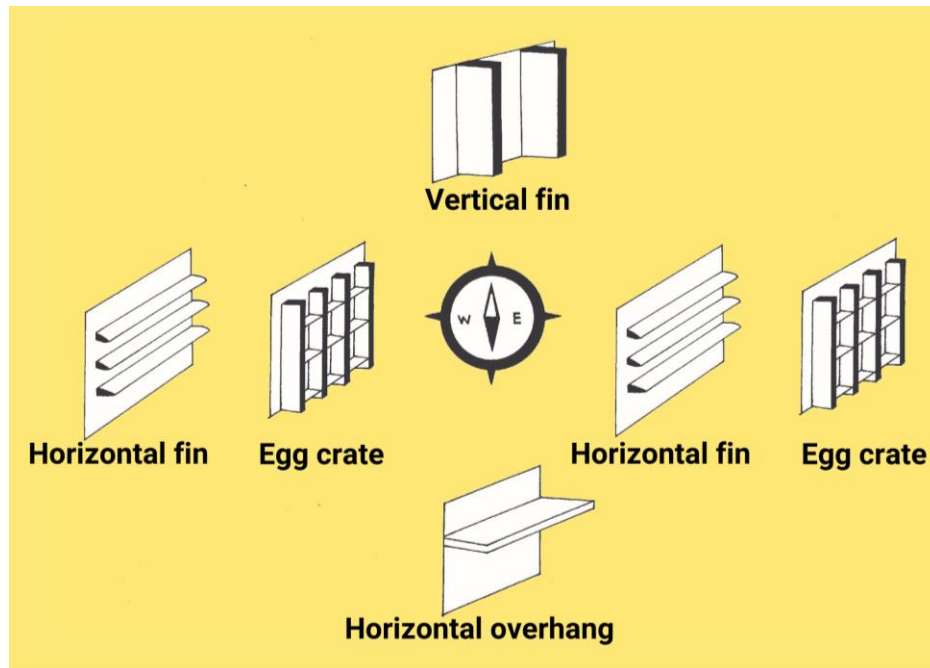


Fig 8: External Shading Devices and their orientations

Internal Shading

Curtains and blinds help to control the movement of sunlight from inside the house. Internal blinds can help exercise finer control over how much heat and light is allowed into the room, but the external shade is the first line of defence against direct sun and heat.

- **Insulation**

An Insulator is a poor heat conductor, meaning that it becomes difficult for the heat to pass through. It is used in buildings to control the temperature inside the home, regardless of the weather outside. In hot climates, for example, insulation helps keep heat outside the building, while in cold climates, insulation helps keep the heat inside the building.

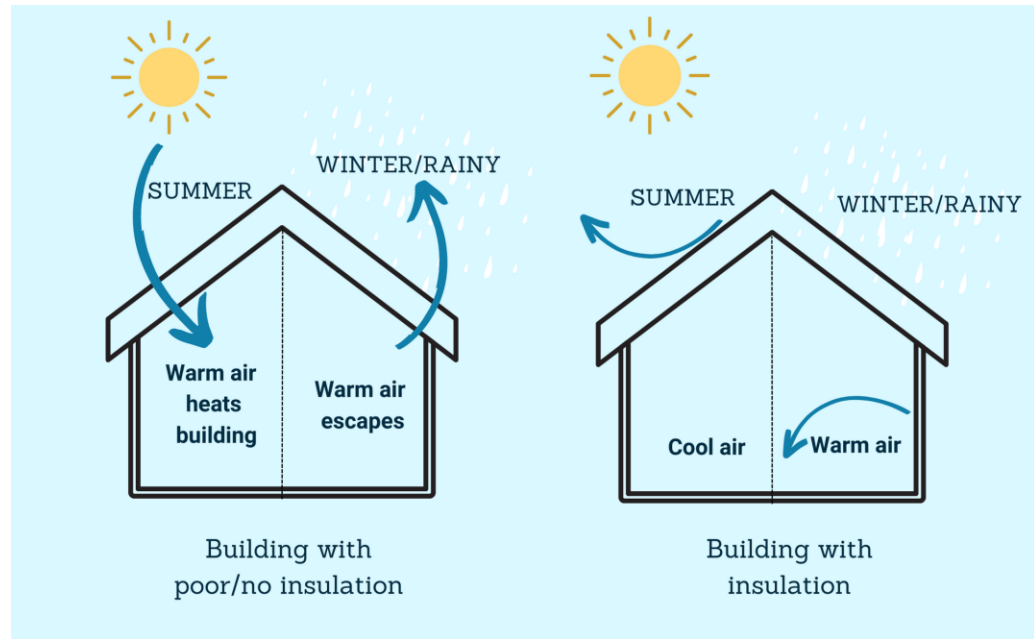


Fig 9: Insulation and its Impact (Insulated vs Uninsulated Home)

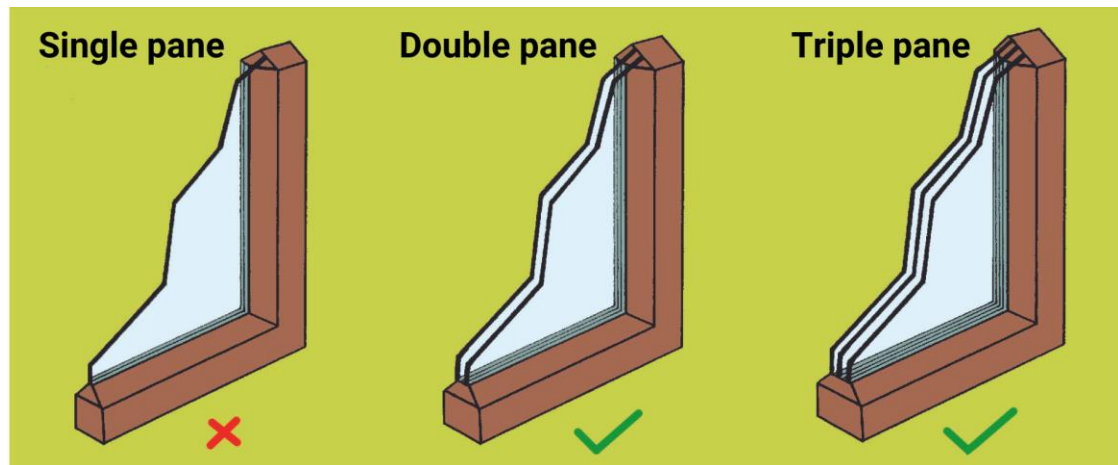


Fig 10: Insulated window pane to prevent heat escape

Finally, one must ensure that there are no air gaps between the walls, roof, and windows when building your home. This is because air gaps allow air to enter from the outside or leave from the inside of your home.

- **Natural Ventilation**

Natural ventilation can also help to cool a room in hotter climates. This cooling effect can help save money on energy bills by reducing the use of fans, coolers, and air conditioners. Natural ventilation can also be improved by implementing the following strategies:

- Window openings in a house to be placed in the path of wind flows from the outside.
- Placement of these openings at a height suitable enough to allow natural breeze to flow through the rooms at a comfortable level.

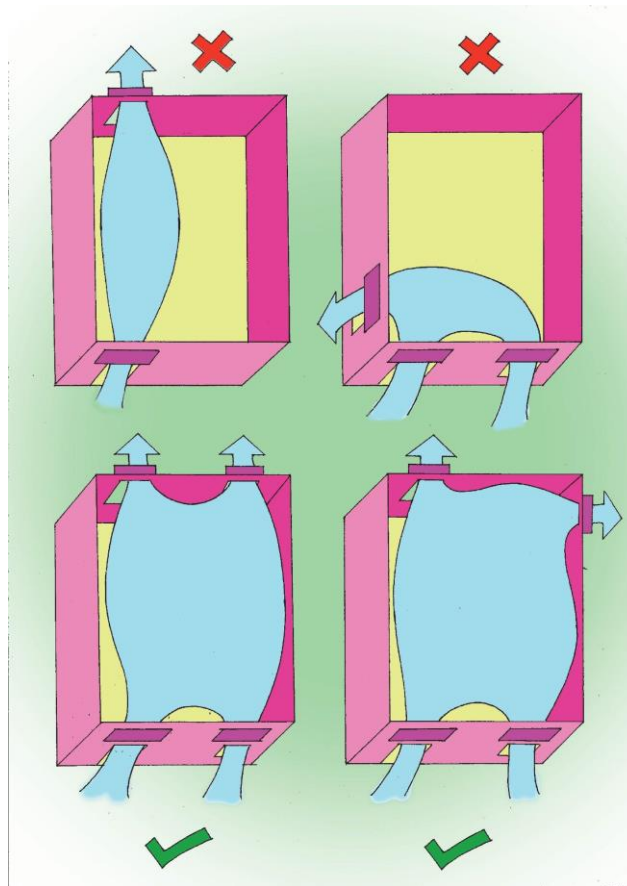


Fig 11: Cross Ventilation

- **Cool Roof**

In hotter climates, cool roofs are used, keeping heat out of a house. The roof is exposed to the sun throughout the day, which heats it up and transfers it inside. Choosing the right roof finish can help save money on cooling costs by shading and providing insulation.

The majority of solar radiation falling on rooftops is reflected by cool roofs. For instance,

- **Green roofs** are rooftop gardens. The soil and plants will aid in roof insulation, lowering overall heating and cooling costs. These have the potential to reduce the "urban heat island" effect. (An urban heat island (UHI) is a city that is much warmer than its surrounding rural areas, due to human activities.) These also provide easily accessible green spaces in increasingly urbanized areas.
- **Reflective Surface**
By painting roofs with white reflective paint and overlaying the surface with white ceramic broken tiles, etc., a roof can be turned into a cool roof. This will reduce the need for air conditioning and make a home more comfortable.

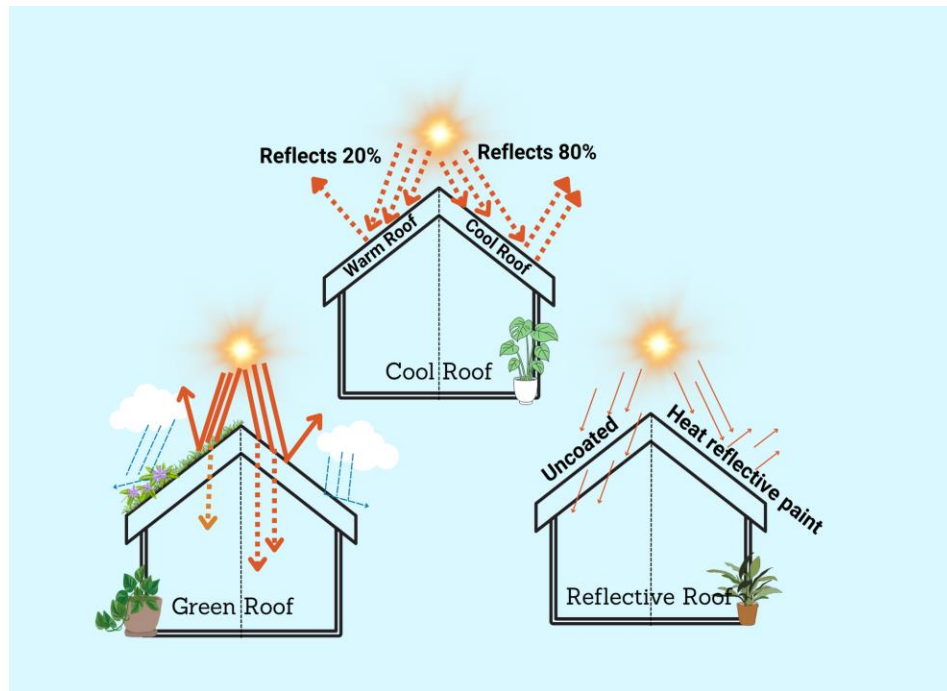


Fig 12: Cool, Green & Reflective Roofs

Chapter 3

Electrical layout

An electrical layout is a visual representation of the circuit, electrical systems and their various components. With the help of defined symbols and lines, it showcases and describes the location of the electrical appliances. One of the main components of an electrical layout is to represent all the circuits in the house. Each circuit is a closed loop with the current originating at the service panel and returning to the service panel on the neutral wire.

The electrical layout is important to document for information sharing and for planning any modifications in the power system of the house.

A detailed electrical layout contains a lot of information:

- Cable routing and wire interconnection.
- Cable path and details such as sizes, capacity and rating.
- Main switches, breakers, fuse plugs and their positions.
- Other electrical equipment like power diesel generator, solar panel, batteries etc.

Proper planning of electrical work is essential for designing safe and energy-efficient buildings. It ensures proper power distribution to various appliances as per their rated capacity.

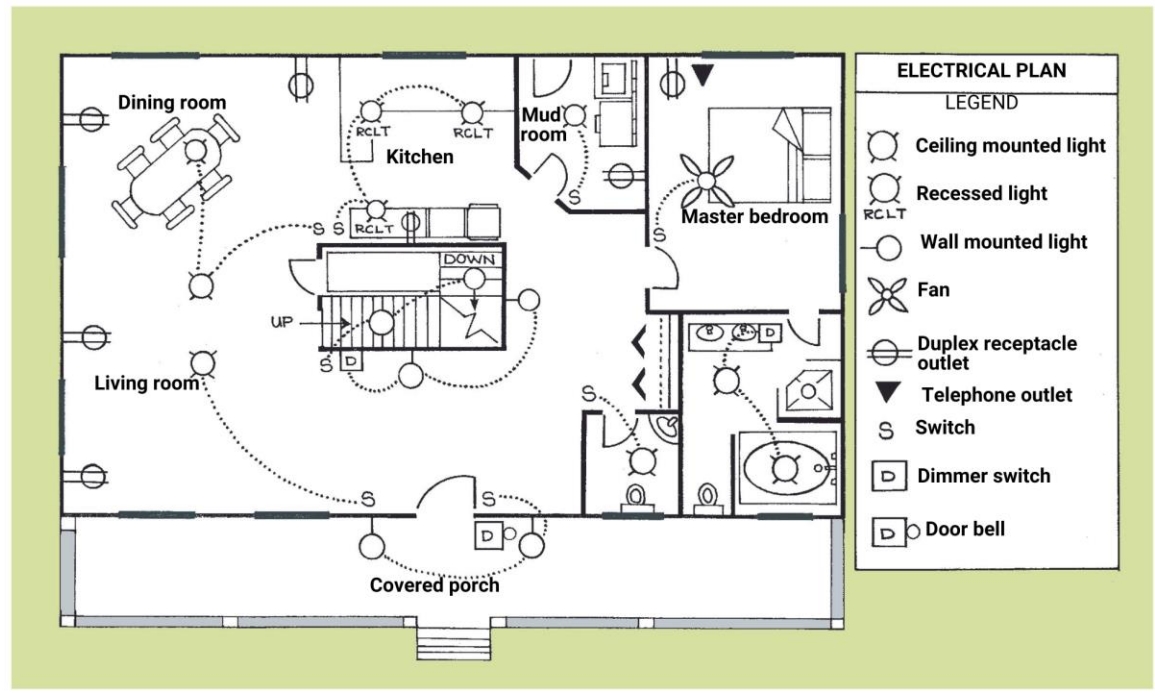


Fig 13: A typical home electrical layout | Source: [CAD Pro](#)

Checklist to draft an electrical layout:

- Calculate how many sockets are needed per room.
- Calculate what kind of electrical appliances are needed to be connected in each room.
- Calculate the rated capacity of electrical appliances and load per room.
- Identify the location of the switch and plug per room.
- Calculate wire rated capacity based on electrical load per electrical board.

Fundamental electrical terminologies:

- *Power:* Electric power is the rate at which electric energy is transferred by an electric circuit.
- *Energy:* Electric energy is the energy produced by movement of charged particles called electrons.
- *Voltage:* Voltage can be defined as the electric potential difference between two points in an electric circuit.
- *Current:* Electric current is the flow of electricity through a wire or circuit.

The flow of electricity in the house:

Power consumed in the house is generated in the power plant some distance away. Through many transmission and distribution lines, it reaches the building at 230 volts and 50 Hz.

The main energy meter of the building is connected to the service head through the main power cable. These connections are made by power distribution companies. Further house wiring from the energy meter to the internal house is the homeowner's responsibility. The main distribution box acts as the load centre of the house. It distributes electrical power into individual circuits throughout the home and also provides circuit breakers or fuses which can be used to shut off any individual circuits in case of emergency or any repair work.

Power consumption is measured in kiloWatt hours (kWh). It is also called a unit. Energy meters can register and store every unit of power consumed in the building. The Energy Meters are fixed by the Electricity Distribution Company (DISCOM), which are responsible for the network of power lines, underground cables, substations etc., that supply electricity to residential buildings or commercial or for industry etc in the area. Based on the reading, the DISCOM prepares the electricity bill. The consumer's electricity bill is dependent on the accuracy of energy meter readings installed in the house.

Nowadays new kinds of energy meters are also available in the market called smart energy meters. These meters not only record, but also store units of power used by consumers but also communicate the data to electricity distribution company on a real-time basis. This enables avoidance of manual reading and recording of information by the DISCOMs.

A checklist for the main distribution box:

- Smart energy meters
- Individual circuit connections with fuse box/breaker box
- All wiring systems to be connected to the earth

Wiring aspects and selection of wires:

Wires and cables are the main components of the home electrical infrastructure. Selecting proper capacity wire with standard quality ensures smooth and safe electricity flow. Wire selection considering certain aspects as explained below is a crucial part of the electrical assembly process of a building.

Conductivity: Wires allow current to flow from one circuit to another. The higher the conductivity of wires, the less the current loss in the form of heat, which results in lower electricity bills. Copper wires have more conductivity and are safer than aluminium wires. Hence they are preferred over aluminium wires.

Insulation: Current always flows on the outer surface of the wire so insulation is required to protect against shock. Usually, wires are insulated by rubber or plastic vinyl materials. PVC insulated wires are cheap and durable.

Thickness: Wire thickness mainly depends on the current-carrying capacity. Different electrical appliances need different levels of current to perform their functions; hence the size of the wire will vary with the appliance. The below table explains the wires to be used for each appliance.

The thickness of wires	Types of equipment can be connected
1.5 sq. mm	Lights, fans, charging plug
2.5 sq. mm	Geyser, high power kitchen appliances microwave oven, grills
4 sq. mm	Split or window type of air conditioner
1.5 sq. mm or less than that	Earth wire

Identification of wire:

Proper colour coding should be used while wiring houses. In a three-phase system, red(R), black(B) and green(G) colour should be used for live, neutral and earthing wires, respectively. Then, based on the requirements the wires can be drawn from the main distribution box to the respective switchboards.







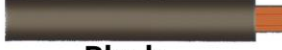

	SINGLE PHASE	THREE PHASE
PHASE CONDUCTOR (Line)	 Red or  Yellow or  Blue	 Line 1 Red  Line 2 Yellow  Line 3 Blue
NEUTRAL CONDUCTOR	 Black	
PROTECTIVE CONDUCTOR (Earth)	 Green and Yellow	

Fig 14: Wire Color Coding

How to do appropriate wiring:

The connection between the two wires (phase wires and neutral wire) should be fairly strong and fully insulated. Damaged or improperly joined wires may result in a short circuit and cause a fire.

One must be aware of the approximate power consumption of the building before proceeding with wiring. The entire appliance list must be taken into consideration and the power consumption must be calculated based upon the operating hours.

The location of all sockets or electrical board points must be decided in advance and marked properly. Wiring can be done by chiselling off the walls and fixing the conduit pipes. It should be ensured that the conduit pipes are well insulated to avoid electrocution. The two types of wiring are discussed below.

(i) Conduit Wiring

In an electrical system, electrical conduits are used to protect and route electrical wiring. Electrical conduits can be rigid or flexible and are generally made of metal, plastic, or fiber. It is to be done by the electricians by following standard regulations. It gives safety and protection against fire.

Advantages of Conduit Wiring

- Provides safety.
- Gives a better appearance.
- Eliminates risks of fire.
- Eliminates cable insulation damage.
- Lasts longer.
- No risk of getting a shock.

Disadvantages of Conduit Wiring

- Expensive to install.
- Not easy to install.
- Detecting fault is not easy.
- Cannot be easily customized for future use.

(ii) Concealed Wiring

As the name suggests, concealed wiring is hidden. It is laborious to install and involves wiring inside the floors or walls and further concealed by plastering the walls or floors.

Advantages of Concealed Wiring

- Safer as compared to open wiring.
- Provides a better appearance.
- Eliminates the risk of fire.
- Safety against damage to the insulated cable.
- Eliminates the risk of getting a shock.
- Lasts longer.

Disadvantages of concealed wiring

- Expensive to install.
- Not easy to install.
- Cannot be easily customised for use in the future.
- Difficult to locate faults if any.

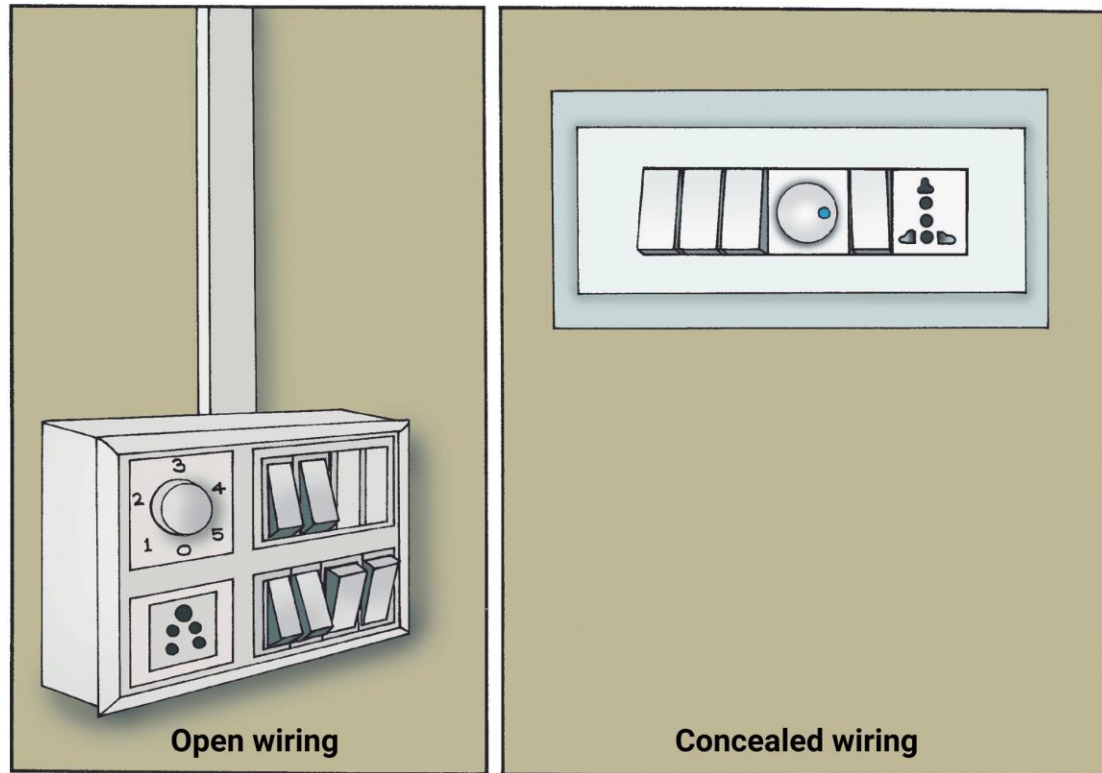


Fig 15: Difference between open and concealed wiring

The electrical wiring must comply with regulations like National Electrical Code of India and be configured with safety utmost in mind.

A graphical representation of electrical installations with the help of predefined standard symbols, is called a single line diagram. In this diagram, each circuit is represented by a single line only. Apart from the circuit, the single-line diagram also shows the power capacity and sizes of electrical equipment. A well-illustrated diagram represents power flow distribution from the main source to downstream loads in the house.

In addition, one can maintain a single line diagram of the wiring for future references for any modification or maintenance purpose in building a wiring system.

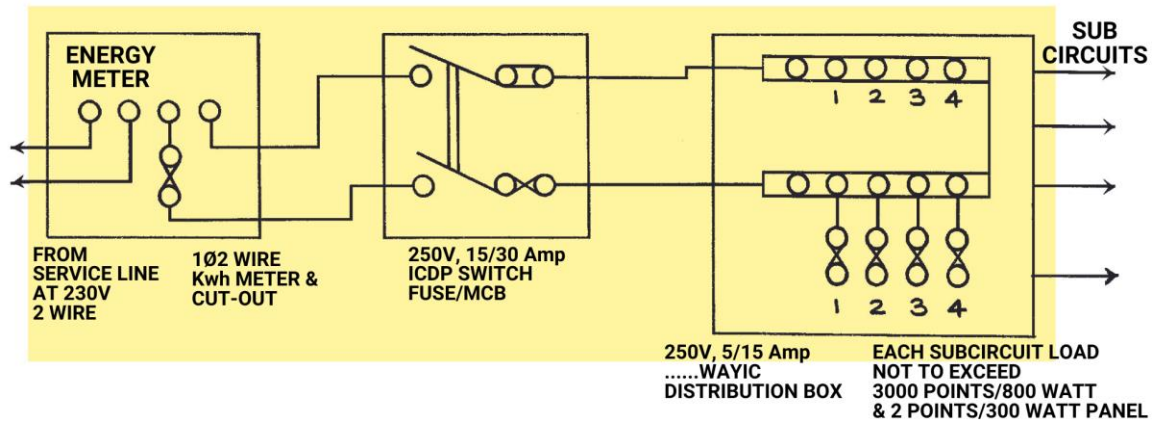


Fig 16: Single Line Diagram for house wiring

Checklist:

- Too many wires should not be drawn through concealed/open conduits. A maximum of 9 wires can be drawn through 1" conduit and 6 wires through ¾" conduit. This will avoid overheating of the wires and further prevent short circuits.
- Separate circuits are to be provided for each geyser and AC power outlet.
- A maximum of 2 numbers of 16A socket outlets can be connected to one circuit to prevent overloading or overheating of the cable wire.
- Each circuit of the wiring should have separate phases, neutrals and earth wires. Neutral or earth wires should not be connected in loops. From every switch point, separate phase and neutral wires should be laid to the individual electrical fittings.

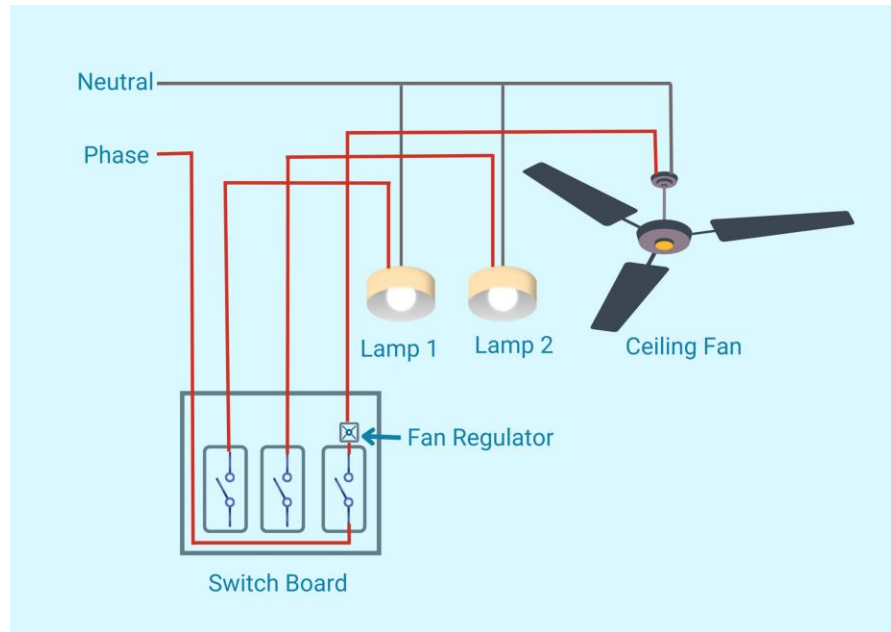


Fig 17: Circuit Wiring connection

Earthing:

It is essential to provide earthing facilities to protect the appliance and for the safety of users. Earthing is explained briefly in the coming chapters.

Once completed with the above-mentioned points, the switches, sockets, and regulators can be added to the switchboard. It is necessary to provide provisions for the installation of additional appliances in the future.

Wiring safety checklist:

- Do not perform the wiring, when the power supply is ON.
- Never perform any wiring operation with wet hands.
- Choose the correct size of cable to handle the exact load.
- Check whether the correct voltage is supplied, or else it may affect the performance of the appliance and result in damage to the product.

Considerations for future maintenance:

- Regularly check the wires and cables to avoid problems in the future
- Immediately replace the damaged wires and cables
- Avoid overloading appliances at one plug point. If multiple outlets are required at any point, it is advisable to provide more socket outlets during the construction itself.

- Selection of the right type of extension cords and their proper usage following safety aspects like avoidance of overloading, loose connections and handling in wet conditions should be ensured.

Chapter 4

Selection of electrical materials

Introduction to electrical materials

It is important that the electrical materials, such as wires and other electrical fittings at your house meet specified standards to ensure that they are durable and unaffected by weather conditions. The wiring, which plays an important role, must also protect the occupants of the house from electrical leakage, shock, and fire threats. Accessibility is a crucial factor in positioning electrical fittings and outlets. The switches and plug points given must be conveniently accessible, and there must be provision for extending the wiring system in the future if necessary. Maintenance costs must be kept to a minimum, and the wires must be resistant to mechanical damage.

In general, the electrical materials are classified as wires, conduits & bends, switches, sockets, switchboards/boxes, safety devices and other accessories to electrical appliances. While choosing these materials, it is important to consider the accessibility of sourcing the materials as the aesthetic appearance might be good for eyes but might not be easily available in the future. Also, consumers should not compromise on the Standards formulated for the electrical materials as this might affect the safety of the occupants.

There are further details on electrical materials that one should be aware of, which are discussed in detail in the respective sections.

Wires

There are several electrical appliances used in a household and all of these appliances are connected through wires and cables for their functions. In most of the cases, the word wires and cables are used interchangeably, but the cables are a collection of many wires. Multiple wiring materials which constitute a wiring system will ensure a safe, sound living environment and play an important role in protecting the occupants of the house from electrical leakage, shock and fire threats. Hence the important factor to be considered while selecting the wires are mentioned in this section.

- Type of wire and material

- Nature of load
- Safety of the system
- Dampness
- Corrosive fumes
- Fire hazards or other special conditions
- Construction of building

Specification for wires

- Copper flexible wires made of Poly Vinyl Chloride (PVC) are commonly used in wiring. PVC is an insulating substance that encases tiny copper wires.
- Single-phase power is typically provided at 220 V, with wire insulation rated at 660 V or 1100 V.
- FR/FRLS (Fire Resistant/ Flame Retardant Low Smoke) wires are fire retardant, while super grade wires are both fire retardant and low smoke.
- Flexible PVCcopper wires are now available in diameters of 0.75 mm², 1.0 mm², 1.5 mm², 2.5 mm², and 4.0 mm².
- To choose the right size of wire to use for cost-effective wiring, consider the overall load of the building, rooms, and so on.
- Earth wire is typically 0.75 mm².
 - 1kW load may be absorbed by 1.0 mm² (6 Amp.).
 - 1.5 mm² is suitable for 1.5 kW (7-8 amp) loads, while
 - 2.5 mm² is suitable for 2.5 kW loads (16-17 Amp.).
- It is mandatory to use Standard ISI marked wires. Cheap wires which do not have the ISI mark should not be used as they are unsafe.

Specifications for conduit Pipes

- PVC wire is drawn to various locations within the home using PVC conduit pipes, such as the roof ceiling, walls, and ground.
- During construction, 25 mm heavy duty (ISI designated) pipe should be used in Lanter (beam or horizontal slab used to support the structure of windows, doors, etc). If the pipe is disregarded, it may break, allowing civil (cement, sand, concrete, etc.) materials used during the lanter's construction to enter the pipe and restrict its passage for drawing wires.

- To save money, medium weight pipes (roughly 0.59kg for 100 mm wall thickness) can be used for walls.
- After laying pipes with steel wires and bars, all concealed lightboxes, fan boxes, and other boxes should be correctly tied. All holes should be covered with polythene or similar materials.
- It is always recommended to utilise 60-65 percent diameter pipe for laying/drawing wires through it to ensure the system's long life while also allowing for future use if necessary.
- The hidden layout of pipes through lantern should be based on the size of the space, as well as how many fans, lights, and other items will be used in the premises.
- Heavy-hooked fan boxes should always be used.
- All switch boxes should be installed/fastened at appropriate locations in the rooms, normally 1.2 metres from the floor level, and connected with a conduit pipe.
- Chipping should be done on walls so that the pipe is approximately 1" deep and covered with plaster; otherwise, the plaster covering the pipe will split.

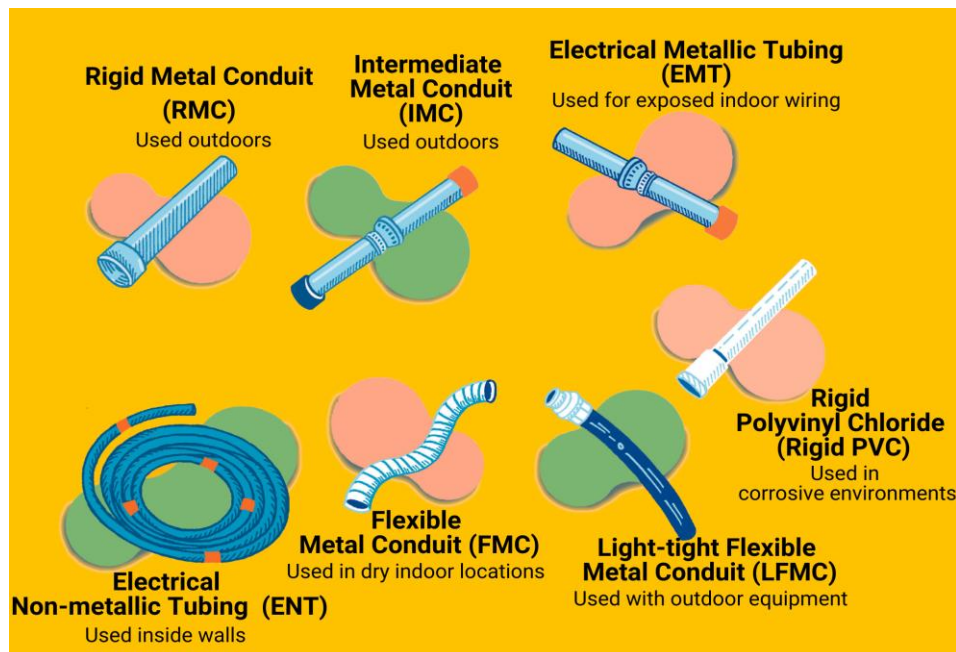


Fig 18: Types of Conduit Pipes and their use

Specifications for other Accessories:

- 6A switch, 6 Amp. 5 pin socket, 16A/20A switch, 16/20 Amp. 6-pin socket, AC plug point, fan regulator, dummy, plates, cover plate, etc., 2-way switch 6Amp / 16 Amp are used generally.
- 6A switch is used for all light points, fan points, etc.
- When connecting low power rated equipment such as mobile chargers, LED TVs, audio-video equipment, table lamps, laptops etc using 6A sockets (also called low power sockets), a 6A switch is recommended. There are several types of low-power sockets available: 2 pins, 2/3 pins, 5 pins, and universal sockets are among the options available.
- High Power sockets (to prevent electrocution) come in three different ratings: 16A, 6/16A, and 25A. They are used for heavy electronic appliances with metal bodies like geysers, air conditioners, washing machines, room heaters, kitchen appliances, and water pumps. Accordingly, a 16A/20A switch and 16A/20A 6-pin socket can be used.
- The fan speed is controlled by the fan regulator. In the market, there are numerous varieties of regulators: 4 steps, 5 steps, and full rotation. To achieve maximum efficiency with less power wastage (through heat loss), use the 5 steps type regulator which gives you 5 different fan speeds, is easy to use, and can be rotated 360 degrees.

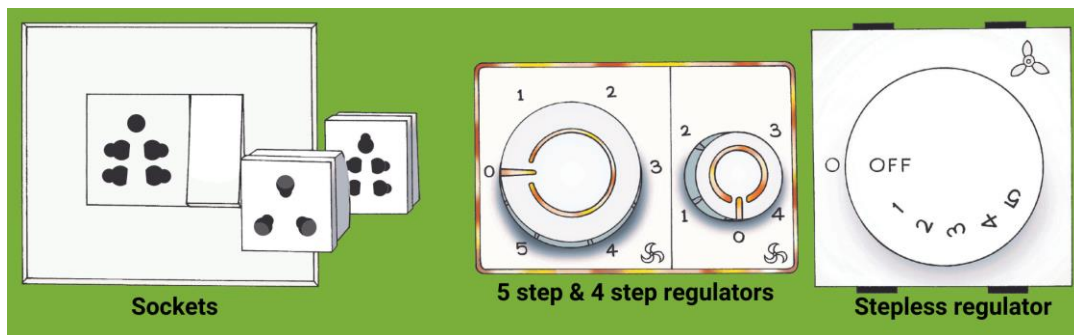


Fig 19: Switch sockets and regulators(5 step, 4 step and stepless)

- The cover plate is used to cover all the switches, sockets, etc. with the matching colour of the walls.
- 2 way switches are used for staircase light control and entry gate lights
- Ensure that all the accessories are ISI marked.
- After completing all wiring connections, it should be checked again for any loose connection. Operation of all points, MCB tripping and ELCB operation should also be checked.
- Undesired nails, screws, and cut pieces of wires should be removed to avoid any injury.
- Each metal & switch box should be earthed for human safety.
- Joints should always be avoided.
- Mark room wise location on the MCB and Distribution Board.

It is necessary to select materials considering the following aspects in mind:

- It is necessary to ensure that the materials selected can be sustained for a longer period with spare parts available easily at times of repair. One must try to avoid materials that are on the verge of becoming obsolete.
- The cost of the material also plays an important role in material selection. One must prefer materials that serve the required purpose as well as are cost-effective.
- Selecting a suitable cable size for the application is important. A better understanding of local conditions, installation setup, and maintenance are essential as it helps in the proper selection of the cable and ensures that the selected cable system will operate satisfactorily.
- The switches and plug points must be installed at convenient and accessible places, with provisions for extending the wiring system incase of future necessities.

To ensure safety in the electrical and related works, and the right use of the appliance, the Bureau of Indian Standards (BIS) has formulated certain rules and regulations. The five principles followed are

- Safety
- Ease of use and adaptability
- Simple technology
- Value for money products
- Energy efficiency and environment

Some of the Indian Standards, Codes and their applications are mentioned below:

STANDARD	CODE	SECTION	APPLICATION
IS-723 (1989)	Code for the practice of electrical wiring applications	Electrical Installation	Design of installation, selection, and erection of equipment, inspection, and testing of the wiring system
IS-3034 (1987)	Code for practice for earthing	Electrical Installation	Design, installation, and calculation of earthing system
IS-3070 (1993)	Lightning arrestor alternating current system	Electrotechnical; Surge arrestors	Identification, rating, classification, testing procedure for arrestors.

In addition, one can check for ISI marks on the wires. The ISI marks indicate that the products comply with the standards mentioned by BIS. The products are certified based on the testing, inspection, and quality control check conducted by supervisors.

Selection of safety devices:

Electricity is our best friend if we handle it properly. It is important to know the

protective devices that need to be installed in a household to prevent electrocutions, short circuits and electrical fires, mainly caused due to faulty wiring or earth faults.

Protective devices:

Protective devices shield the electrical circuits from troubles like extreme voltage or current. This consequently shields the home appliances from damage and fire.

Protective devices for electrical circuits undertake two main utilities such as consistency and protection. In this, protection is guaranteed by way of detaching the power supply, and is also called overcurrent protection. The devices are beneficial for the protection of circuits as they protect the appliances from extreme voltage or current which can damage them and also cause fire.

Why do we need it?

Protective devices are necessary to protect consumers, and electrical equipment or appliance against

- a) Short Circuit
- b) Overloading of equipment
- c) Abnormal variations in the supply voltage
- d) Electrical shocks due to accidental contact with faulty equipment.

Different kinds of protective devices that are commonly used in electronic and electric circuit

1. Fuse
2. Miniature circuit breaker (MCB)
3. Moulded Case Circuit Breaker (MCCB)
4. Residual Current Circuit Breaker (RCCB)
5. Residual Current Circuit Breaker with Overload protection (RCBO)
6. Earth Leakage Circuit Breaker (ELCB)
7. Safety Plastics Caps
8. Ground Fault Circuit Interrupter (GFCI)

These devices are explained in detail in chapter 8.

Choosing the power backup system: Inverter and Battery

Power backup can be provided by an (i) Uninterruptible Power Supply (UPS), (ii) Inverter and battery system, and (iii) Generator. Out of these, inverter and battery

systems are mostly preferred for domestic usage. Selecting an inverter and battery system for a household is explained below.

Consider a consumer in a 2 BHK house who wants to connect their tube light, LED bulb, fans and electrical socket (to connect mobile charger or wifi).

Appliances	Quantity	Wattage	Power requirement
Tube light	4	36	144
LED bulbs	5	12	60
Fans	4	75	300
Socket	4	15	60
Total power requirement			564 watts

Note: It is always advisable to connect specific appliances with lower wattage rather than the entire appliances in the household. Energy efficient appliances like LED tube light or bulbs, BLDC fans will help consumers to conserve energy as well as reduce the capacity of inverter and battery.

Step 2: Calculating inverter capacity

Inverter capacity is mentioned in VA (volt ampere) i.e., the voltage and current supplied by the inverter to connected appliances. Generally, inverters have an efficiency range between 60% and 80%. This efficiency is also called the Power factor of an inverter i.e., the ratio of power required by the appliances to power supplied by the inverter. The average value of power factor of an inverter is considered as 0.7.

Power supplied (or VA rating of an inverter) = Power required by the appliance (in watts) / Power factor (efficiency).

Considering the above eg, the inverter capacity for the total power requirement of 564 watts will be = $(564/0.7) = 805$ VA.

Hence an inverter with a rating higher than 805 VA will be a right choice for the consumer. However, it should not be too high though. It is also important to note the voltage supported by the inverter as this will help in choosing the right battery capacity.

Step 3: Calculating battery capacity:

Generally, consumers will be seeking to know how many hours an inverter will support or provide backup when there is a power cut. This can be determined by calculating the battery capacity.

The performance and life of an inverter will largely depend upon battery quality. Battery capacity is mentioned in Ah (ampere hours).

Let us consider a battery that needs to provide a backup support for 4 hours during power cut. In the above example, a consumer requires a battery capacity for an inverter of 805 VA capacity, then the total VAh needed = $805 \times 4 = 3,220$ VAh

A regular inverter battery available in the market is 12 V, 24 V and 36 V.

If the inverter supports 12 v, the Ah value of battery required would be $3,220 / 12 = 268.33$ Ah. Hence a consumer could choose two 150 Ah batteries and connect them in parallel.

If the inverter supports 24 v, the Ah value of battery required would be: $3,220 / 24 = 134$ Ah. Hence a single 150 AH battery would be sufficient for the consumer.

Chapter 5

Selection of appliances

The selection of electrical appliances is an important criterion since the electricity bill of a household mainly depends on this. Also, choosing inappropriate electrical appliances can be injurious **to health and life**.

Introduction to BEE:

As technology advances with innovation, the usage of electrical appliances has been tremendously increasing, thus increasing energy consumption in the society. The Bureau of Energy Efficiency (BEE) was set up by the Government of India in 2002 with the primary objective of reducing the energy intensity of the Indian economy. In 2006, the Standards & Labeling Program was launched under BEE to lay out an informed choice before the consumers about the energy and cost saving potentials of the electrical appliances.

The BEE's star label or power saving guide found on appliances in India provides details about the appliances' energy consumption, efficiency or efficacy along with other essential information like the label period. Currently, the scheme covers 12 mandatory appliances and 19 voluntary appliances, listed below:

MANDATORY APPLIANCES	VOLUNTARY APPLIANCES
<ol style="list-style-type: none">1. Frost Free Refrigerator2. Stationary Storage Type Electric Water Heater3. Colour Television4. Room Air Conditioner (Variable Speed)5. Room Air Conditioner (Fixed Speed)6. Tubular Fluorescent Lamps (TFL)	<ol style="list-style-type: none">1. Computer2. Domestic Gas Stove3. General Purpose Industrial Motor4. Submersible Pump Set5. Washing Machine (Semi/Top Load/Front Load)6. Ballast7. Solid State Inverter8. Office Automation Products9. Diesel Engine Driven

7. LED Lamps 8. Room Air Conditioner (Cassette, Floor Standing Tower, Ceiling, Corner AC) 9. Distribution Transformer 10. Direct Cool Refrigerator 11. Ceiling Fan 12. Refrigerators (Valid From 01-01-2023)	MonosetPumps for Agricultural Purposes 10. Diesel Generator Set 11. Chillers 12. Microwave Oven 13. Solar Water Heater 14. Deep Freezers 15. Light Commercial AC Fixed Speed 16. Ultra-High Definition (UHD) Televisions 17. Air Compressors 18. Tyres/Tires 19. High Energy Li-Battery
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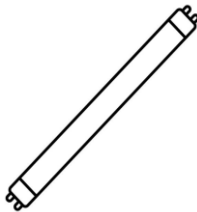


Requirements of the buildings and consumers' usage pattern

a. Lighting

The main usage of lighting appliances is to provide optimal lighting with which day to day tasks can be carried out. While consumers mostly look at the wattage of lights/lamps, it is also important to study the lumens of a lighting appliance. The value of lumens will determine the brightness of light that lights/lamps emit. The different types of lights used in the residential sector are:

- Incandescent bulbs
- Compact Fluorescent Lamps (CFL)
- Fluorescent tube lights
- Light Emitting Diodes (LED)

Of these, LED bulbs, and LED tubelights are energy efficient and consume less power.

ECONOMICS OF LIGHTS				
	Incandescent	Fluorescent	CFL	LED
				
Lumen/Watt/Hour	11.67	73.61	48	80.60
Units (kWh) consumed in a year	131.40	78.80	32.80	21.90
Life span (hours)	1200	15000	10000	50000
Cost Per Bulb (Rs)	12	85	200	950
Number of bulbs needed for 50,000 hours	42	3	5	1
Cost of electricity consumed a year (Rs 5.50/unit)	722.70	433.62	180.40	120.45
Total cost of electricity & bulbs for 50,000 hours	28,000	10,155	7,325	5,900

The amount of lighting power required for a given area is termed as Lighting Power Density (LPD). The below table explains the lighting required in each space.

Common Space Type	LPD (W/ft²)
Conference/Meeting/Multipurpose	1.23
Corridor/Transition	0.66
Dining Area	0.65
Electrical/Mechanical	0.95
Food Preparation	0.99
Lobby	0.99
Lobby for Elevator	0.64
Lounge/Recreation	0.73
Office: Enclosed	1.11
Office: Open Plan	1.11
Restrooms	0.98
Stairway	0.69
Storage	0.63
Workshop	1.59

- Look for lumens in addition to wattage while choosing the bulb. Higher the lumens, the brighter the space.
- Ensure the right beam angle for the bulb by fixing it in the centre of the room.

The higher the beam angle the more the space is covered with brightness.

- Choose the colour temperature based on the interior design and look. Color temperature is a way to describe the light appearance provided by a light bulb. It is measured in degrees of Kelvin (K) on a scale from 1,000 to 10,000. Typically, Kelvin temperatures for commercial and residential lighting applications fall on a scale from 2000K to 6500K.

S.no	Temperature range	Referred as	Colour range
1	2000K to 3000K	Warm White	Orange to Yellow
2	3100K to 4500K	Cool White or Neutral White	Neutral white to slightly blue
3	Above 4500K	Daylight	Blue white tint

- Colour temperature with lower Kelvin will be best for eyesight since higher Kelvin has a blue light effect. Prolonged exposure to blue light can lead to muscular degeneration, causing permanent vision changes like difficulty in seeing the centre of the field of vision.
- Buy fixtures that have a dimmer, which allow you to manually adjust the intensity of light in a room. Most lights use less electricity at lower settings, so, you do not need to pay for more light than you need.
- Use photocells or timers to switch off exterior lights during the day.
- Use occupancy sensors in toilets/washrooms so that the lights inside will work when people occupy the rooms and will automatically switch off after they leave within a pre-fixed time.

b. Fans

Consumers are generally unaware of how much energy a ceiling fan consumes, as well as the additional costs associated with energy-inefficient ceiling fans. A ceiling fan is the most commonly utilised device in most Indian homes. For small rooms of around 100 sq ft, the fans must be in the centre of the room; for open-plan living areas, ceiling fans just above the center of the lounge or tower fans directly facing occupants can be used.

Air delivery: When purchasing a ceiling fan, one of the most crucial elements to consider is air delivery. It denotes how much air a fan can move in a minute or how

well a fan can convert electrical energy into moving air (measured in cubic metre per minute (Cu m/min)). When air delivery is increased, the amount of air blown out by the ceiling fan increases as well, making us feel more comfortable.

Power input: The declared power input of a fan denotes its energy consumption value. Comparison and consideration of this factor while the purchase can result in efficient appliance selection.

Fan speed: Any ceiling fan's speed can be identified from the mentioned RPM value. RPM is the Rotations Per Minute of its blades. To understand the air circulated and to select an efficient fan, its RPM value is to be considered.

Sweep Size: The size of the ceiling fans are measured along with the diameter of the blade length in mm or inches and determined as Sweep size. If the usage area is smaller, lesser sweep size ceiling fans can be selected. The below image shows how to measure the ceiling fan. Generally, ceiling fans are available with the seep size of 900 mm, 1200 mm, and 1400 mm (the sizes will vary for different manufactures and varies from model to model)

Star rating: The Bureau of Energy Efficiency (BEE) has presented a star rating system for 1200 mm fans. The star rating of ceiling fans are determined using the “service value” of a fan. Service value denotes the air delivery in metre cube/min, divided by electrical power input to the fan in watts (W) at test voltage and at full speed. In simple terms, service value means the amount of air delivered per minute per wattage of electricity.

For instance, a regular ceiling fan uses 75-80 watts, and a BEE 5-star rated fan uses only 50-55 watts. It is to be kept in mind that the star rating system changes during certain intervals (it is updated every 2 years for internationally manufactured electronic products) consequently, a fan rated 5-star according to the standards in 2020 may not be as efficient as a five-star rated fan from 2022. Consumers believe that BEE 5-star rated fans deliver less air and may not provide the same level of comfort as a regular fan. However, research conducted by Bijli Bachao (a website that provides information related to electricity consumption) found no difference in comfort between a regular fan and a BEE 5-star certified fan. The table below gives a comparison between regular, BEE 5 Star rated, and super efficient fans in terms of price, regulator cost, power consumed, air delivered, annual unit consumption, annual electricity cost and cumulative electricity cost for 10 years (assuming cost increases 4 percent every year).

ECONOMICS OF CEILING FAN			
	Regular Fan	BEE 5 Star Rated Fan	Super Efficient Fan
Price (Rs)	1500	1940	2600
Regulator Cost (Rs)	200	200	0
Wattage (W)	75	50	35
Air Delivery (cum/min)	230	210-220	230
Units Consumed Per Year	180	120	84
Electricity Cost Per Year (Rs)	900	600	420
Electricity Cost For 10 Years (Rs)	10800	7200	5000

For sweep size <1200 i.e., for blade sweep of 900 mm and 1050 mm the following would be the star rating plan.

Star Rating	Service Value
1 star	≥ 3.1 to < 3.6
2 star	≥ 3.6 to < 4.1
3 star	≥ 4.1 to < 4.6
4 star	≥ 4.6 to < 5.1
5 star	≥ 5.1

(Valid from the 1st July, 2022 to 31st December, 2024)

For sweep size ≥ 1200 mm i.e., for blade sweep of 1200 mm, 1400 mm, and 1500 mm the star rating plan would be as shown in the table below. As is apparent, only the 1 star rated value varies with the three different sweep sizes.

Star Rating	Service Value
1 star	≥ 4.0 to < 4.5 for 1200 mm ≥ 4.1 to < 4.5 for 1400 mm ≥ 4.3 to < 4.5 for 1500 mm
2 star	≥ 4.5 to < 5.0
3 star	≥ 5.0 to $< 5.$
4 star	≥ 5.5 to < 6.0
5 star	≥ 6.0

Energy-efficient innovative fans: Some fans deliver better air with less power input. At full speed, it employs a Brushless DC (BLDC) motor that consumes 28 watts of power. Brushless fans are more efficient than conventional fans and BEE 5-star rated fans, consuming 135 units per year vs 384 units and 255 units per year for normal fans and BEE 5-star rated fans, respectively. These BLDC fans are also called Energy efficient fans or Super Efficient Fans, or Gorilla fans. The table below compares and contrasts different fan technologies.

Technical Details	BLDC fans	5 Star rated fans	Normal fans
Power consumption (W)	28	53	80
Air delivery (Cu m/min)	230	210	230
Service value	8.2	4.0	2.9
Total Bill (Rs.6/unit)	806.4	1526.4	2304
Price INR (Approx.)	3000	1500	975

c. Air Conditioners

Air conditioners (AC) are used to not only provide cooling but also maintain comfortable humidity levels and adequate freshness of the indoor air hence consume huge amounts of electricity. It is always advisable to buy BEE-certified star-rated air conditioners. High Star-rated appliances are more efficient in design and consume less energy compared to no or low-star-rated ACs under the same operating conditions.

ISEER Value – The Indian Seasonal Energy Efficiency Ratio (ISEER) is used to determine an air conditioner's star rating. The ratio of Cooling Seasonal Total Load (CSTL) to Cooling Seasonal Energy Consumption (CSEC) is known as ISEER, where CSTL is the total annual amount of heat that the equipment can remove from an interior space when it is in use and CSEC is the total annual amount of energy that the equipment consumes during the same time period. The higher the CSTL/CSEC (star rating) ratio for the device, the more energy efficient it is.

For window and Split, AC star rating and corresponding ISEER rating is mentioned below (Source: BEE website):

Windows Air Conditioners

Split Air Conditioners

(From 1st January, 2021 to 31st December, 2023)

Indian Seasonal Energy Efficiency Ratio (kWh/kWh)		
Star level	Minimum	Maximum
1 Star	2.7	2.89
2 Star	2.9	3.09
3 Star	3.1	3.29
4 Star	3.3	3.49
5 Star	3.5	

(From 1st January, 2021 to 31st December, 2023)

Indian Seasonal Energy Efficiency Ratio (kWh/kWh)		
Star level	Minimum	Maximum
1 Star	3.3	3.49
2 Star	3.5	3.79
3 Star	3.8	4.39
4 Star	4.4	4.99
5 Star	5.0";	

Size of AC:

The selection of an appropriate size of AC is critical to achieving required thermal comfort in the minimum time with the least energy consumption. AC capacity depends on the following factors:

- 1- Area to be cooled
- 2- Occupancy of area
- 3- Other appliances that are placed in the area.

The greater the area to be cooled, the more the tons of cooling required and hence the need to select a bigger AC. (The units used to measure cooling capacity are a ton of refrigeration or watt.) With more people and more electrical appliances in the area, more fresh air replacement is required to maintain freshness and comfortable humidity levels.

An ideal AC size calculation for a typical room with less than 5 people:

Room Size (in sq. ft)	AC Capacity (in tons)
Upto 100	0.8
Upto 150	1.0
Upto 250	1.5
Upto 400	2.0

Label period:

At regular periods, BEE updates the energy efficiency criteria. A 5-star-rated Split AC with a label term of 2018-2020, for example, may be regarded as a 3-star-rated in the year 2021-2023. As a result, it's critical to examine the star rating label's labelling era.

AC model & year of manufacturing:

The star rating label will also include the model number of a particular brand. Because the star rating will change in accordance with technological developments in energy-efficient items, the year of manufacture is just as significant as the star rating.

Cooling capacity:

It is the amount of cooling produced by an AC or its ability to remove heat from a space. A one-ton AC has a cooling capacity of around 3500 watts.

Electricity consumption:

The star label will indicate the annual electricity consumed by the appliance under test settings; however, this may vary depending on usage patterns and climatic conditions.

Type of compressor:

Compressors with variable and set speeds are extensively utilised in air conditioners. Non-inverter type ACs will have a fixed type compression, whereas inverter type ACs will have a variable speed compressor, which is more energy efficient.

Heat pump:

In the northern portions of India, where the summers and winters are harsh, air conditioners with heat pumps are employed. Heat pumps and air conditioners work together to deliver both cooling and heating. The purpose of a heat pump is the polar opposite of that of an air conditioner. A heat pump is a mode that collects heat from the outside and pushes it into a room. If the air conditioner has a heat pump, it will be noted on the star label.

Things to consider about Inverter AC

Inverter ACs take more time to achieve the desired cooling temperature but maintain this temperature throughout the operation period without any fluctuations. They do this by adjusting their compressor speed to maintain a set temperature level. On the other hand, non-inverter based ACs work on fixed speed and auto-shut down when the desired temperature is achieved; with rising the temperature up to a few degrees the compressor starts again with full speed. They never maintain the same level of temperature - a few degree fluctuations are inherent in the operation. Typically if AC operational hours are high (for example, more than 8 hours a day), inverter ACs are the more economical option.

d. Refrigerators

Modern living has made refrigerators necessary appliances. Refrigerators are a long-term investment, so consumers should consider buying an energy-efficient (5 star rated) refrigerator.

(i) Size: It is important to decide the size of the refrigerator which suits the household size. The selection of a suitable capacity refrigerator is very important because running a half-filled refrigerator amounts to wasting energy. Refrigerators' compressors regularly go for on or off positions at regular intervals. This process leads to more electricity consumption as the compressor works at a uniform speed.

Inverter technology, on the other hand, allows the compressor to operate at various speeds to give the appropriate output based on cooling requirements. The inverter will shift the compressor to a lesser capacity when the temperature falls below the predefined levels. When cooling is required, however, the compressor will return to full capacity. Inverter type refrigerators are the best, known for their long life and low energy consumption.

With inverter technology, a consumer can save up to 20 – 30% on electricity consumption. Even in stable temperatures, you can still save up to 20 – 40% electricity.

Frost-free is another feature available in modern refrigerators that help prevent the accumulation of frost inside the freezer compartment. Using special electric fans, this innovative technique distributes chilled air evenly throughout the refrigerator. Side-by-side, double-door, and triple-door refrigerators all include this technology. They consume more electricity than the other ones. However, they have a longer

life span. Look for the ENERGY STAR label (or BEE i.e. Bureau of Energy Efficiency stars) before buying. More stars imply more energy efficiency.

Understanding cooling technology:

For wise and effective efforts to save energy while running your fridge, it becomes essential to understand how the cooling process in your device takes place. The following cooling processes are most widely used:

- **Direct Cooling:** found in the single-door refrigerator, works through vapor condensation (water vapor turns into liquid) and natural convection (air-fan circulation). Frosting on the cooling coil reduces its cooling efficiency. Such fridges need to be defrosted either manually or automatically. They cost less than frost-free models, have low maintenance costs, and consume less energy.
- **Frost-Free:** Found in the multi-door refrigerator, consumes more electricity and costs more. Works with the help of a timer that activates the heating coil around the cooling coil, melting the frost. The heating stops when the temperature rises above zero degrees. The cold air from the freezer section is usually ducted to the fresh food compartment and then circulated back to the freezer.

Pick a refrigerator that comes with two separate temperature controls for the food compartment and freezer individually. With a single control, both sections might not function to their fullest potential.

With regards to energy conservation, it is always advisable to buy a BEE star-rated appliance.

Note: New star rating essentially means that if one buys a 2star frost-free refrigerator in 2019, it is as energy efficient as a 4star one bought in 2017 or a 5star in 2015. Same way, a 2-star AC of 2019 would be as efficient as a 3star AC of 2017. Thus, it is erroneous to say that appliances will get dearer as one won't have to pay more for the same model as the price of the model should remain the same, only its rating will be downgraded. This also means that the lowest efficiency models will get removed from the market, forcing people to buy more efficient cooling appliances and in turn reducing per capita energy demand.

BEE's constant notification of products that do not match the specified label rating is one of the initiatives. Before you buy an appliance, check the BEE's website to see if the item is listed as having false labels.

e. Chimneys

- A chimney's suction capacity depends on the power of the motor to suck the fumes in an hour. It is often measured in cubic metres per hour.
- Stoves located further away from the outside will necessitate chimneys with long ducts. Long ducts reduce sucking strength and impede performance. Some modern kitchens have the stove located in the sidewalls, requiring several turns and bends of the chimney ducts, reducing efficiency significantly.
- If your kitchen is in a small space with a lot of humidity, appropriate ventilation and air movement are essential. In that situation, a chimney with a duct will ensure appropriate ventilation for your kitchen.
- You won't need a chimney with ducts if your kitchen is already ventilated with windows and exhaust fans. Unless they are vented lower to the stove, a ductless chimney will suffice.
- If you know the volume of your kitchen, you can readily determine suction power.
- The volume of your kitchen is calculated as follows: Height (m) x Width (m) x Length (m)
- When you know the volume of your kitchen (mm³), multiply it by the efficiency factor, which is usually 10.

$\text{Suction force of chimney} = \text{volume of your kitchen} * 10$
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- Any chimney you choose must be higher than the suction power you receive. A chimney has a minimum suction power of 270mm³.

f. Washing Machines

Consumers need to choose a washing machine based on their family needs since laundry requirements vary from household to household. Given below are the specific factors a consumer can consider before buying a washing machine.

(i) *Capacity and Size*: the loading capacity of the washing machine is expressed in kg and it should be decided based on the number of family members and approximate washing cycles.

Family members	Tank Capacity
1 - 2 members	5 to 6 kg
2 - 3 members	6.5 to 7 kg
4 - 5 members	8 kg
More than 5 members	More than 8.5 kg

In addition to this, a consumer has to consider the space available in the household to fit the washing machine comfortably.

(ii) *Washing Machine function types*: Depending upon the manual interventions and number of functions, washing machines are categorized into two categories - a) Semi-Automatic and b) Fully Automatic.

- a) Semi-Automatic - these are entry-level washing machines which have been available in the Indian market for decades. They require much human intervention. In this type, there will be two tubs or compartments, one for washing and another one for spin-dry cycles. A consumer needs to put clothes in the washing tub for washing and water also needs to be filled either by pipeline or through a bucket. In both cases, consumers need to ensure the right amount of water is required for washing. Once the washing is done, the consumer only needs to transfer the clothes to the spin-dry tub. Also, a consumer can add clothes midway through a cycle.
- b) Fully Automatic - Nowadays, with the help of technology, washing becomes easier without the need for human intervention. As the name proposes, the device is fully automatic and does not need human intervention. A consumer needs to load the machine and run it.

(iii) *Loading types*: There are two types of loading types - a) Top loading,

b) Frontloading

- a) Top Loading: As the name suggests, in the top-loading washing machines, clothes are loaded from the top. In this machine, the tub is placed vertically. Top-loading washers are normally more convenient since consumers don't

have to bend over to load or unload the clothes making them the ideal height for older buyers and those with joint issues i.e. it's ergonomically friendly. It also has other convenient qualities such as the ability to add clothes mid-cycle or right after starting the cycle since the door does not lock. It distributes the detergent and clothes softener better than front-loading washers. (Semi-automatic machines are always top-load machines.) Top-load machines also have smaller wash cycles that require less time; but they are a bit rough on fabrics as compared to front-load machines.

- b) Front loading: In this type, clothes are loaded from the front of the washing machines. Front-loading washers are more water-efficient since they use an average of 40% less water than top-loading washing machines since it has tumbling action. In addition to this, front-loading washing machines are much gentler, give a smoother wash cycle, and can wash delicate clothes very easily. On comparing with top load, the front load has various washing features and programs.

Voltage stabilizer for appliances

In locations where there are high voltage fluctuations, it is recommended to provide voltage stabilizers to reduce energy losses and avoid damages to the equipment due to low or high voltage. Almost all electronic and electrical equipment are designed to work on defined voltage and set frequency. The household commonly used voltage range is 240 V and frequency is 50 Hz. If voltage fluctuations are more than 10% below or above this range, the electrical appliance may fail to function or even get damaged. Voltage stabilizers keep the voltage within a certain range and supplies almost constant voltage supply to the connected appliance. Nowadays modern appliances like refrigerators, washing machines or even AC have an in-built stabilizer; they therefore do not need an external stabilizer.

Selection of voltage stabilizer for appliances:

A voltage stabilizer can be sized based on how much total watt (power load) is connected to it. Total power consumption in watts can be the voltage stabilizer size. However, nowadays the stabilizer rating is in VA or kVA. In this case, the VA value should approximately be 120% of watts value. If the total connected load is 400 watts then install 480 VA voltage stabilizer for the same.

Some common household appliances like LED TV or refrigerators are designed to work in the long voltage range so they can be operated without voltage stabilizers also. However the sudden surge in voltage because of lightning etc can damage the equipment. Hence a dedicated voltage stabilizer is recommended to use. All other heavy-duty household appliances like washing machines, ACs etc always need a voltage stabilizer for smooth functioning.

Individual small stabilizers for respective appliances are recommended to use when compared to a big voltage stabilizer for the whole house connected load. The reason is usually that stabilizers consume 2-3% power of their rated capacity such as 2000 Watt rated capacity stabilizers consume 1 unit a day. So leaving them on for a longer period can increase the electricity bill.

Chapter 6

Placement of appliances

The exact positioning of an appliance can be decided well in advance during the design stage itself with the help of a floor plan. One must pay attention to the location of doors and windows and their direction of openings. The number of sockets depends upon the size of the room. During the planning stage consultation with masons and electricians can be helpful.

Lights: Accurate location awareness is essential to use lighting effectively, avoid glare and create optimal conditions appropriate to the purpose of the room:

- To ensure a good distribution of illumination, the mounting height should be between 1.5 m and 2.0 m above the work plane with a separation of 2.0 m to 3.0 m between the luminaires. If the ceiling height is more, space between the lights should be more for uniform distribution of light in the room.
- Fixing lights in the ceiling is always recommended because that way maximum luminance is focused unidirectionally downwards where we need light.

FIXTURE SPACING		
Ceiling Height	From Wall	Space Apart
8'	3'	6-7.5'
9'	3.5'	7-8.5'

- Proper spacing in between the light bulb can give a more uniform distribution of light in the room.
- Ensure that there is no obstruction to the light beams.
- Lights can be installed based on the needs of a particular place. For example, a tube light will not be necessary for the restroom where an LED bulb is sufficient.
- Always install lighting fixtures facing downwards.

Fans:

- Minimum clearance between two consecutive fan hooks should be twice the fan size to be fitted.
- The minimum distance between the ceiling fan & floor should be 2.3 m (7.5 ft). No fan should be mounted with its blade closer than 0.61 m (approx 2 ft) to the ceiling.

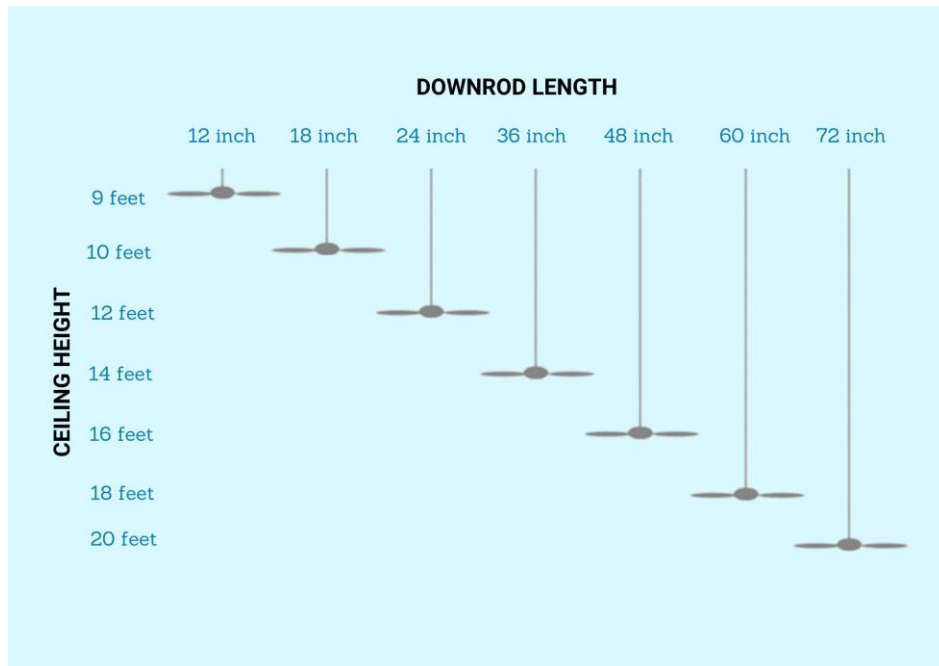


Fig 20: Fan rod length based on ceiling height | Data source: [G Squared Art](#)

Refrigerators:

- Since refrigerators release heat from the back and the bottom, most refrigerator manuals mention clearance space. If not mentioned, provide at least 6 inches of space around it.
- It is better to keep fridges away from sunlight to reduce energy consumption.
- Avoid keeping heat sources like a gas stove, ovens, etc near the refrigerator.
- Keeping the refrigerator in a well-ventilated room will allow cool air to come around it and improve its efficiency.

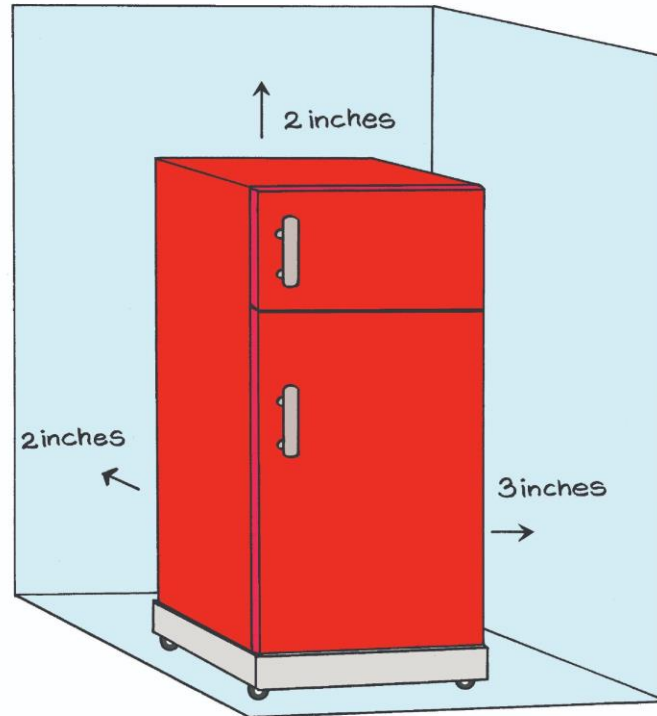


Fig 21: Refrigerator clearance space requirement

Air Conditioners:

- If the building gets direct sunlight, the AC should be placed in the north or south walls, as heat from the buildings will make the appliance work harder to provide the desired amount of cooling.
- Ensure that the condenser of the outdoor unit is installed in a properly ventilated space and has enough space around it for air to circulate and help the refrigerant dissipate its heat easily.
- If a consumer wants to install an AC in a living room, it is recommended to install it towards the sitting position i.e., somewhere that a consumer can direct airflow.
- It is not recommended to fix the AC above any types of electronic equipment such as a TV in a room.
- While fixing the Split AC, the location should be selected in such a way that the refrigerant piping from the indoor unit to the outdoor unit should be done easily with minimum length.
- While fixing the Split AC, the location should be selected in such a way that piping for the condensate drain should be connected easily to a drain point.

This drain point can be inside a toilet/washbasin/sink drain or a separate drain piping.

- If a consumer wants to install an AC in his/her bedroom, it is recommended to install it to the left or right of the bed and not directly facing the bed. Else the cool air falls directly on the consumer making it too cold and uncomfortable, or even causing throat irritation.

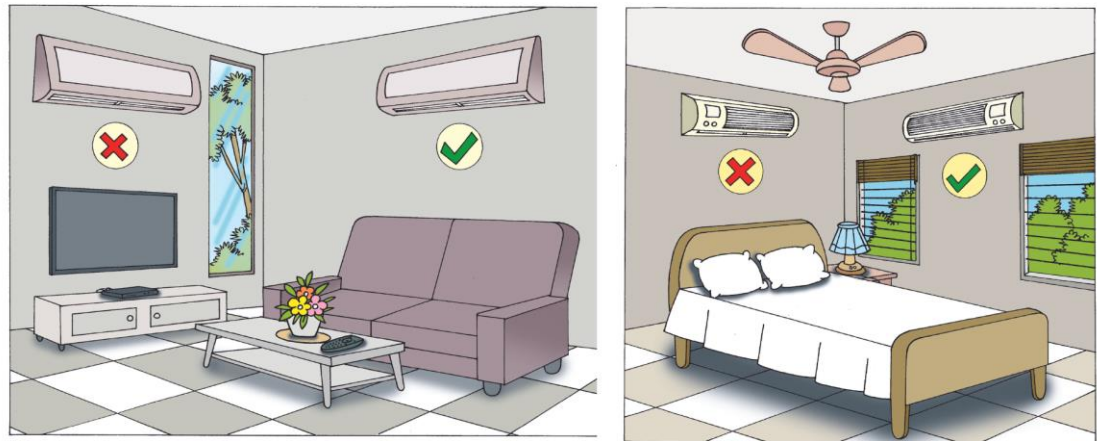


Fig 22: Placement of AC in a bed room & living room

Geysers:

- Make sure there is a proper connection from the water source to the heater.
- A secure electrical connection is necessary to avoid shocks. It is important to place it around three feet away from a 230 V electrical outlet with correct grounding.
- Verify that the wall can support a weight that is at least twice that of the water heater when it is fully stocked with water.
- It is advisable to fix the switch of the Geyser outside the bathroom to avoid using the switches with wet hands and water splashing onto the switches.
- 6 inches of space around the geyser and the wall is recommended.
- The location of the geyser should be such that it is away from wet areas.

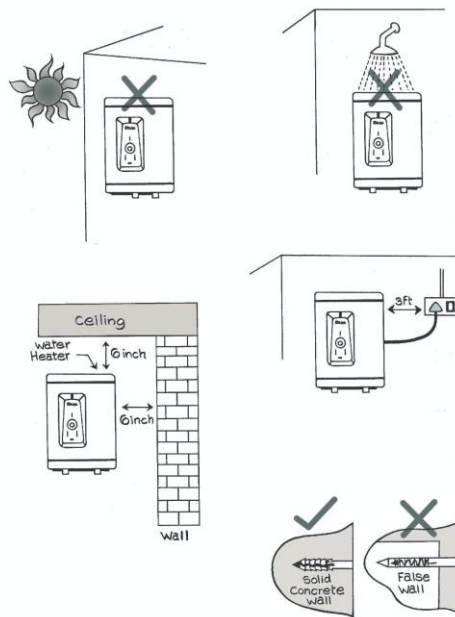


Fig 23: Proper installation of a water heater/geyser | Source: [A.O.Smith](https://www.aosmith.com)

Inverter and battery:

- Inverter and battery should be placed in an area which has a free space around it.
- It should not be exposed to water.
- It is better to choose an area free from sunlight and other hazardous or flammable materials.
- An inverter must be fixed horizontally either on a vertical surface (wall) or on a horizontal surface (floor).
- If the inverter is fixed on the vertical wall, ensure that the wall is not subject to any kind of vibration.
- If the inverter and battery are installed in a customised material fixed with a wheel for movement, ensure to lock the wheels after placement.

Benefits:

Proper planning, selection of good equipment and placement of electrical appliances ensure the safety of the building and also results in higher savings.

Chapter 7

Maintenance of appliances and energy conservation tips

Energy conservation and home appliances usage:

Judicious use and maintenance of home appliances not only helps in saving energy but also contributes towards protecting our environment. Modifying habits through efficient behavioural changes both at home and the workplace is the first step towards energy conservation and efficiency.

Understanding energy units:

Understanding how units of energy work helps us make a start with monitoring home appliance use. The amount of electricity consumed over a period of time is generally measured in Kilowatt-hour(kWh).

Energy conservation and maintenance tips:

- **Lighting:** Normally, every corner of the home does not have provisions to receive natural light, making artificial light sources necessary. Electrical light sources consume roughly 1/6 to 1/5 of the total electricity used in an average household. Lamps and bulbs are the most common lighting appliances in every household. Simple energy conservation measures such as the ones listed below can help save energy at your home.
 - Make use of natural light as much as possible. Adjust curtains and blinds to allow natural light to stream through.

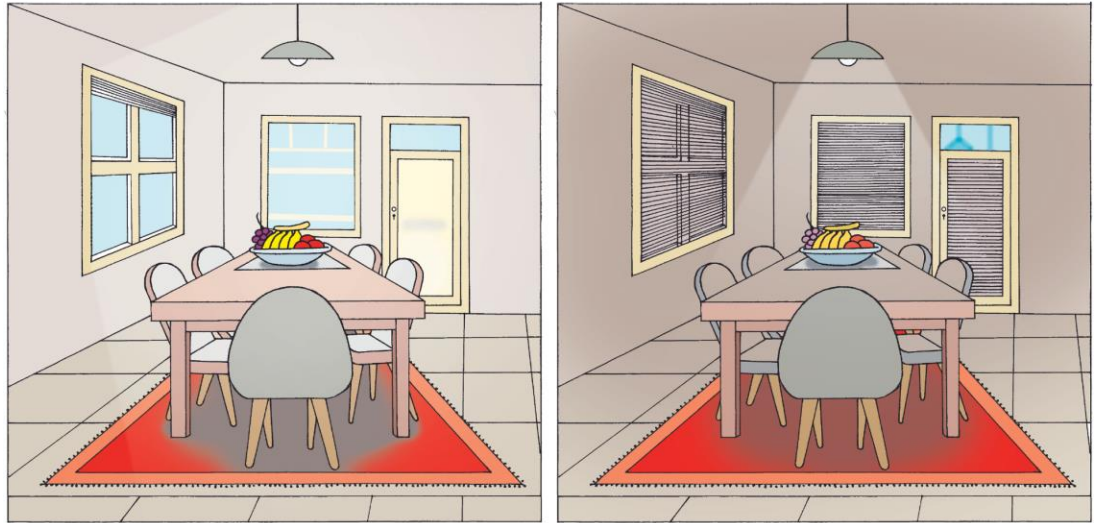


Fig 24: Natural vs Artificial Light

- Use task lighting instead of brightly lighting an entire room. A reading lamp, for example, lights only reading material rather than the whole room, making it a more energy efficient choice.



Fig 25: Task Lighting

- 'SWITCH-OFF' lights when not in use.

- Lighting maintenance has an economic, aesthetic, and work productivity impact; so, it's in the user's best interest to get the most out of lights with the following tip:

Clean dust on light fixtures, lampshades and lighting appliances. Dust, oil, and other accumulations on lamps and reflecting surfaces of the fixture can reduce light output by as much as 30%, making the consumer think they need more lamps or brighter lamps.

- ***Fans/Coolers:*** Running a fan uses far less energy than running an air conditioner. Ceiling fans use about 30-90 Watts on average, which is only a fraction of what an air conditioner will use. While fans are simple devices and generally consume low levels of energy, they can still be made to run even more efficiently using the following tips:
 - Fans with speed regulators are more useful for thermal comfort and also consume less energy at low speeds.
 - Brushless Direct Current fans (or BLDC fans) consume less power and also have longer lifespans.
 - Overheating can cause ceiling fan motor failure. Overheating occurs when dust and other particles accumulate and clog the motor. So regularly dust fans and keep them clean.
 - Avoid using fans that have bent wings or have turned obsolete.
 - Replace fans that have failed due to motor issues. Rewinding is to be avoided as they are very inefficient and consume more power.
 - Moisture causes rusting of motor components such as bearings. To avoid this problem, oil your bearings on a regular basis.
- ***Television, Laptop, and Computer:*** Laptops are designed with energy efficiency and consumption in mind, making them much less power-hungry than their desktop PC counterparts. Use these, rather than desktops, wherever possible. Desktop computers, as well as television sets, are permanently connected to power supply, therefore, the following tips will guide you to conserve energy:
 - 'UNPLUG' the TV/ desktop when not in use
 - Higher volume consumes more energy; keep it low
 - Manually 'SWITCH OFF' the TV, DVD player, etc. at the plug point; switching it off just using a remote controller will consume energy as the appliance remains on stand-by mode.

- Bright screens not only impact health but impact electricity consumption as well.
- Battery chargers should be unplugged or switched off when not in use.
- Setting computers, laptops, monitors, and copiers to sleep mode when not in use saves around 40% on energy expenditures.
- Shut down your computer/laptop at the end of the day(or during the night) and do not keep on sleep mode for a long time, to avoid overheating.
- Avoid overcharging mobile phones, laptops, etc. as this will affect the lifespan of the batteries.
- Routinely inspect your daily use devices for wear and tear. This will extend their lifespan.
- Update your devices from time to time. This will help the device run faster and consume less energy for the same task.
- Dust off the keyboard and other components of laptop and computer systems regularly.
- **Refrigerator:** Refrigerators are used most commonly to store food and other consumables at a temperature that maintains the food product's quality. They run throughout the day and are therefore a constant source of high power consumption, which makes their maintenance essential. The following tips will help with this:
 - Leave at least 6 inches of distance between the wall and the fridge to allow circulation of the hot air generated.
 - Heat enters the refrigerator every time you open the fridge door, consuming more energy to maintain the same temperature. Minimise opening the door.
 - Avoid keeping hot food directly into the fridge. Let it cool down to room temperature first.
 - Cover your food items. Uncovered food items leak moisture, which makes the compressor work harder.
 - Do not overfill your refrigerator: Excessive loading of the refrigerator creates obstructions to the circulation of cold air inside.
 - Do not place the fridge where it is in contact with direct sunlight. The heat from the sunlight makes the fridge have to work harder to keep its insides cool, thus consuming more energy. For the same reason, keep it away from heat sources such as gas stoves, microwave ovens, induction stoves, etc. as well. A 5°C increase in surrounding temperature can result in 20% higher energy consumption.

The following tips will help you prolong the life of your refrigerator :

- Unplug the refrigerator before cleaning it from the inside. You may consider cleaning it every 2 months, tossing out all the unwanted items/leftovers to keep it clean and less crowded.
 - Clean the coil (at least every 6-12 months) depending on the environment you live in. This will prevent dust accumulating on it and creating an insulating effect.
 - Check the gasket (seal) for cool air or moisture escaping out of the door and get it repaired. Replace the refrigerator if old.
 - Regulate the temperature. For *refrigerator* : 0-4 degrees celsius. For the *freezer*: below 0 degrees celsius.
-
- **Air Conditioner:** For most people living in India, air conditioning is perhaps the most important modern invention for comfortable living. Air conditioners today (from window units to central systems) are more energy-efficient and cost-effective than ever before. The energy conservation measures mentioned below will help you reduce your energy expenses:
 - Using a fan as the first choice for summers costs less than using an AC as it consumes fewer units of energy.
 - Use ceiling fans along with your AC; this helps to provide better air movement and better comfort.
 - As per BEE guidelines, it is better to set the thermostat to cut off between 24 to 26 degrees celsius. This is optimal for comfort and saves energy consumption.
 - A false ceiling reduces the volume of air that needs to be cooled, thus reducing electricity bills.
 - Switching 'OFF' the AC at least 30 mins prior to leaving the room using a timer or auto cut-off mode will help to save energy.
 - It is normal practice to provide voltage stabilisers for domestic air conditioners. But the latest types of ACs are supplied with stabilisers inbuilt. In this case, we need not provide additional stabilisers unless otherwise there are heavy voltage fluctuations in the area.
 - If a stabiliser is provided to the AC, the power supply to the stabiliser is also to be switched off while switching off the AC. The stabilisers consume some power even in idle conditions.

- Make sure to close the door, windows and wardrobe doors. The objects inside the room will also absorb the cool air and make the air conditioner work more hours.

The following steps will also help lengthen the life of your AC:

- Periodical maintenance (preferably before the summer) is essential for optimal functioning.
 - Clean the air filter and condenser coil in your air conditioner on a regular basis . Dirty filters reduce the efficiency of air conditioners and block air movement.
 - Try to provide rubber strips at the bottom of the window and door to improve window seal and prevent cold air from escaping.
 - Check the coil for leaks or damage.
 - Unclog drainage pipes for better drainage.
 - Regularly dust off the registers and vents.
- ***Washing Machine:*** A washing machine is another common household appliance that is used in most homes. It is the spinning drum component of the machine which uses the bulk of the energy supplied. The following tips should be considered to help conserve energy while increasing its life:
 - Washing full loads of clothes helps to minimise energy consumed rather than smaller, more frequent washes.
 - Cold wash uses less energy than a hot wash, which also destroys the integrity of your fabrics.
 - If hot water is used, by reducing the temperature setting of the water heater from 60 degrees C to 50 degrees C, consumers could save over 18% of the energy used at the higher setting.
 - To reduce heat loss, always insulate hot water pipes, especially where they run through unheated areas. Never insulate plastic pipes.
 - Avoid leaving the machine in standby mode.

The tips below will help in drying the clothes:

- Separate heavy and light fabrics to save drying time. Light fabrics can be easily air-dried.
- Avoid over drying the laundry.
- Instead of using a dryer, use quicker spin speeds to dry.

The tips below will help lengthen the life of your machine:

- Clean the dispenser and interior of the machine on a regular basis (say every 2 weeks).
- Leave the machine door open post-wash for 15-20 minutes to avoid moisture build-up.
- Keep a check on the hoses.
- **Water heater and geyser:** If not done correctly, heating water in a geyser can be costly. This appliance uses a lot of energy. During winter, this high energy consumption drives up the electricity bill. As a result, it is critical to use your hot water geyser as follows to reduce your monthly electricity bills:
 - Adjust the thermostat settings of your geyser/water heaters to help save on electricity bills. Setting the temperature to 45-50 degrees helps in saving energy as compared to built-in settings of say 60 degrees which excessively heats water, making it unusable without mixing cold water.
 - Avoid keeping it ON all day as the thermostat makes sure that as soon as the water heats up to the desired temperature, the power supply cuts off automatically only to turn on when this heated water reaches normal temperature again. This process continues throughout the day until the switch is turned OFF.
 - By reducing the temperature setting of the water heater from 60°C to 50°C, consumers could save over 18% of the energy used at the higher setting.
 - To reduce heat loss, always insulate hot water pipes, especially where they run through unheated areas. Never insulate plastic pipes.
- **WiFi router:** We cannot imagine life without plugging into the internet! Wifi routers are now present in a large number of homes. Even when not in use, small network equipment like modems and routers tend to stay on at all times, idling and consuming power. This means that whether devices are active or not, they consume the same amount of energy, indicating a growing demand for energy resources.
 - Wifi consumption is proportional to the number of devices connected. As a result, restrict or cancel unnecessary or unknown devices.
 - When not in use, turn off both the wifi router and the adapter.
 - Keep the wifi router close to your device because longer-range wifi requires more energy to pair the connection.

- Regular cleaning is required as dust can affect the working of the router's internal parts.
- Place the router in a moisture-free area, to increase its life.
- **Iron box:** An electric iron is a small, frequently used household appliance whose primary function is to remove wrinkles and creases from clothing and fabrics. The thermostat in the electric irons that we use to press the folds out of our clothes, prevents the iron from becoming too hot if it is turned on and left unattended for a long time. Use the following tips to maximise the life of the appliance and reduce its energy usage:
 - Separate your clothing items according to their materials.
 - Use an appropriate regulator position for ironing.
 - Avoid ironing wet clothes and putting in more water while ironing.
 - Turn off the iron when you have only one or two clothes left for ironing.
 - Irons with automatic temperature cut-off save energy.
 - For steam-irons, use good quality filtered water.
 - Unplug the iron and drain the water reservoir after each usage so that the residual heat from the iron can help to dry it off.
 - Place the iron in a safe place to cool before storing it upright in a cold, dry location.

For Kitchen Appliances

Finding ways to reduce energy use while cooking is worth it, whether your bills are increasing or you're concerned for the environment. Simple ways to ensure that you are saving money (and time!) in the kitchen include learning how to use your appliances like microwave ovens, gas stoves and chimneys efficiently, purchasing smaller ones, and being vigilant about energy consumption. The following tips aid in energy conservation and maintenance of various electrical kitchen appliances:

- **Microwave ovens:**
 - These are generally energy efficient appliances, using 50% less energy than traditional gas/electric stoves.
 - Microwaves cook food from the outside edge toward the centre, so place larger and thicker foods on the exterior side.
 - Generally, the microwave stops working after opening the door. If a consumer finds that the microwave functions even after opening the door, they must report this as an issue to the manufacturer or get it repaired.

- Try using ovens on full load.
- Ovens should not be left running indefinitely.
- ONLY microwave-friendly dishware should be used. Aluminium foil, metal, or dishware with silver or gold boundary should not be used as radiation from the microwave hits these metal objects and are then reflected back, causing fires.
- Using the preprogrammed cooking presets helps save time and energy. .
- Never operate a microwave oven when it is empty.
- Clean your microwave regularly to maintain its longevity.
- **Electric and induction Stoves:** Electric and induction stoves do not use a flame to generate heat and instead rely on electricity. The following tips will help you save energy:
 - Turn OFF the stove a few minutes close to the end of cooking. The stove will retain some heat, even without it running.
 - Flat base utensils are more energy efficient as they make full contact with the cooking coil.
- **Chimney:** Chimneys are used to vent hot exhaust gases from interior spaces to the outdoors. Installing a chimney in your kitchen channelizes smoke outside your space. If you have an electric chimney in your kitchen, the following tips will help it work optimally:
 - When a chimney's suction power is low, it should not be erected at a greater height, or the motor's performance will suffer. If you want to put more distance between the chimney and the oven, look for chimneys with higher exhaust rates.
 - Most chimneys include a duct that serves as a conduit for gases and dust to be vented to the outside. Choose chimneys with shorter ducts. Longer ducts will have more turns and bends, reducing suction capacity. Proper cleaning can restore suction capacity.

Chapter 8

Safety aspects

Understanding the application of safety devices at your home and their importance guides you in handling the electrical circuit when required, and avoiding serious accidents. Although we can't imagine life without power, the fact is that many mishaps, most of which are fire-related, are caused by electrical risks. When a human comes into contact with an electrified electrical circuit or an object that has become energized, such as metal or water, an electric current will flow through them. The current has the potential to induce shock, severe burns, a heart attack, or electrocution (major injury or death from electric shock). Installation of safety devices is extremely important to protect yourself from electrocution or fire in the house.

Most common electrical hazards

- **Faulty or Damaged Wiring**

Wires or cables that are not working should be removed right away. Loose, frayed, or exposed wires in cables should be addressed and replaced. Electric shocks and flames can be caused by damaged wires and cables.

- **Overloading Circuits**

If a circuit has too many items plugged in, the current will heat the wires to dangerously high temperatures, perhaps causing a fire. Arcing (commonly mentioned as 'electric spark') may occur if the wire insulation melts, causing a fire in the location where the overload exists or even inside a wall.

- **Use of Extension Cords**

Extension cords are prone to cracks and other flaws, which can cause shocks.

- **Water Spill on Electrical Devices**

Electrocution is substantially increased by water, especially if the equipment's insulation is destroyed.

- **Improper Grounding**

Ground fault current has a direct effect on human safety, as it can result in flames and electrical shock. Furthermore, ungrounding electrical systems might be dangerous to your gadgets.

- **Loose Fitting Plugs**

Be aware that loose-fitting plugs have the potential to overheat and catch fire.

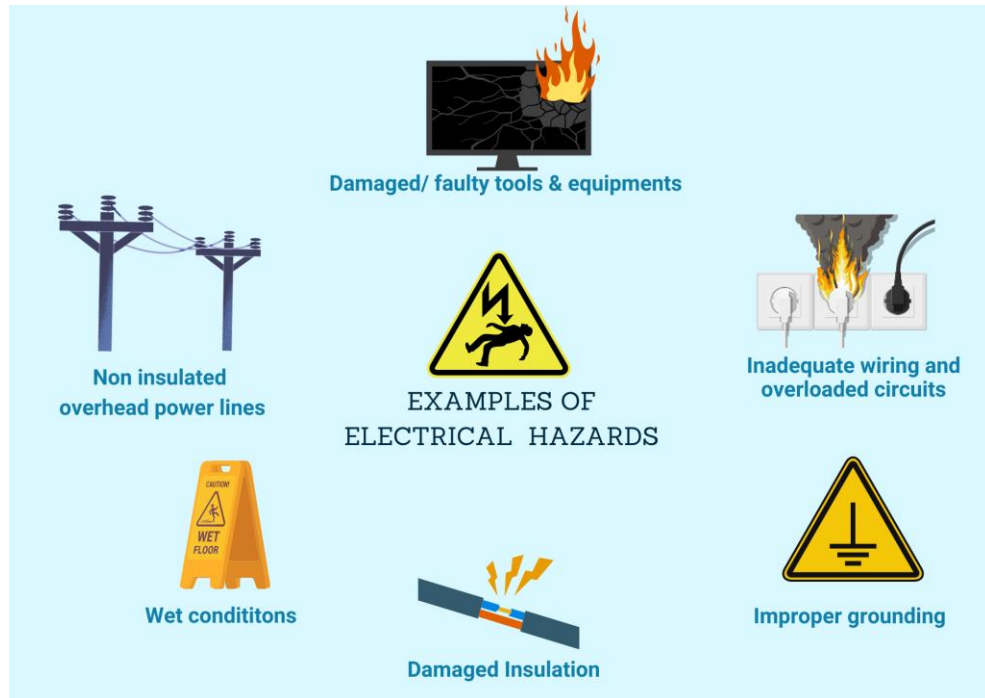


Fig 26: Electric hazards

Safety devices to be installed to protect the electrical circuits

1. Fuse

In electrical circuits, a fuse is an electrical device used to guard the circuit from overcurrent. It involves a metal strip that liquefies when the flow of current through it is high. If a failure in an appliance causes too much current to flow, the fuse will blow and the circuit will be broken. This safeguards the wires and the appliance.

2. Ground fault circuit interrupters (GFCIs)

Ground fault circuit interrupter has a solid-state trip unit. It detects ground currents (which are small short circuits from one phase to the ground) and trips to protect both people and equipment. It is a fast-acting circuit breaker that may cut off electric power in as little as 1/40 of a second in the event of a ground fault. Its functions are

People Protection

This breaker type automatically senses hot wire to ground faults and trips the breaker when a ground fault exists. It is most commonly used in bathrooms,

kitchens, swimming pool areas, and outdoor receptacles. It senses ground faults at 5 milliamps, a level low enough to protect people.

Equipment Protection

This breaker type is designed to protect equipment against damage from arcing ground faults. It is typically applied to computers, process control, and heating equipment. The circuit breaker trips at 30 milliamps.

3. Electrical isolators should be provided in buildings for safe maintenance works. During service and maintenance, isolators will be used to isolate the circuits from the power source.

4. Circuit Breaker: An electrical circuit breaker is a switching device that can be operated manually and automatically for controlling and protecting an electrical power system.

In addition to isolators, protective devices such as fuse units, one can also install

- MCB (Miniature Circuit Breaker),
- MCCB (Moulded Case Circuit Breakers),
- RCCB (Residual Current Circuit Breaker) or Residual Current Device (RCD)
- RCBO (Residual Current Circuit Breaker with Overload protection)
- ELCB (Earth Leakage Circuit Breaker) should be provided in buildings as per the design requirements to protect the electric circuits.

Fuse units are the oldest type of protection system in electrical circuits. This protects the system by disconnecting the electric current flow to the system by blowing off the fuse. The other circuit breakers are explained below.

a. Miniature Circuit Breaker (MCB):

Have you ever wondered what happens to the electrical appliances in your home when there is an overflow of current or a short circuit? These devices catch fire or get burned if proper circuit breakers are not installed with devices. MCB is a small device which is very popular and fitted to the Distribution Board (generally termed as DB box) in most households. MCB automatically cuts off/trips out the power supply in case of high voltage or some other fault in the electrical circuit. It gives protection against short-circuit and overload current, thus preventing current overflow in other electrical devices.

Working of an MCB

- An MCB is an automated switch that opens when a circuit has too much current flowing through it. It can be reclosed without the need for any manual intervention.
- Unlike MCB, a fuse depending on the type, must be changed or rewired after it has been used. This is the primary reason why MCBs are commonly utilized in place of fuses in most circuits. In addition, whenever a circuit fault occurs, the MCB automatically shuts down, allowing the problem of the device to be easily discovered.

Types of MCBs

It is important to choose the correct sizing of the breaker. An oversized breaker will not trip under low fault or high overloading condition, and an under-sized breaker will trip even under normal condition. To work adequately, the MCB should be at 125% of the circuit's current.

Steps to choose the right MCB

- MCBs are available in different types. Analyze the types of MCBs and select according to the requirement. There are six of them namely, A,B,C,D, K, and Z. These trip off the circuit when current exceeds the actual current rating as follows:
 - Type A - 2-3 times
 - Type B - 3-5 times
 - Type C - 5-10 times
 - Type D - 10-20 times
 - Type K - 8-12 times
 - Type Z - 2-3 times
- For home appliances with a medium current load, Type C MCBs are the most appropriate. When the flow of current is 5–10 times greater than typical, a Type C MCB trips off. Because they can endure up to 10–20 times the present rate, Type D MCBs have strong resistance. Type D is the best option if you need circuit breakers for equipment with a large starting current load, like a motor. The Type K MCB can be utilised for heavy load devices because it can sustain up to 8–12 times the initial charge.
- Load used by home appliances are as follows:
 - LED Lamps: 0.2W-40W available for household use

- Fans: 50-100W
- Air Conditioners: 1500W-2500W
- Refrigerators: 190W-300W
- Water heaters: 1500W-2500W
- Iron Box: 200W-300W

Note: Detailed load chart is explained in Annexure -1

Advantages of MCB

- Protects the home from circuit overload.
- Can be reset manually, quickly restores the current supply, and handles a larger amount of power.
- Various appliances like iron, heaters, and lighting systems of the house can be easily used when connected to an MCB as it prevents overload or fault when in use.

Disadvantage of MCB

- Expensive as compared to fuse.

b. Moulded Case Circuit Breaker (MCCB):

MCCB is another type of protective device which provides protection against overload, short circuit, and over temperatures. MCCBs are available in current ratings ranging from 15 Amps to 2500 Amps making them usable in both low and high-powered applications. However, considering its wide current ratings and high breaking capacity, MCCBs are used in industrial applications.

c. Residual Current Circuit Breaker (RCCB):

RCCB is also known as Residual Current Device (RCD) as it protects against the residual current.

Residual current means the flow of leakage current between live wire to earth. Current can flow in two different paths; one is via neutral and another one is via earth. Under normal conditions an electrical load is always connected in between the phase terminal and neutral terminal, hence the flow of the phase current (load current) is equal to the neutral current. Consider an earth fault that occurs in the

electrical load, which means the leakage current starts to flow through a new path, from phase terminal to earth. This leakage current is called residual current.

RCCB is specially designed to protect the electrical circuit against earth faults and humans from electrical shock. This differential current sensing device can automatically measure and disconnect the circuit immediately when a fault occurs in the connected circuit or whenever the current exceeds the rated sensitivity. The RCCB provides protection from small current leakage arising due to accidental touch by human beings or insulation failure, which is not possible by MCB alone.

Types of RCCBs:

RCCBs are generally available in two types, namely 2 pole RCCB and 4 pole RCCB. A single phase supply will have a live and neutral wire, hence a 2 pole RCCB is used. A three phase supply will have three live wires and a neutral wire, hence a 4 pole RCCB is used. In both these types of RCCBs, a rotary switch is used to switch the RCCB back to ON or OFF positions. A test button is also provided to periodically test the RCCB functionality. When the test button is depressed, the test circuit's current begins to flow. The RCCB trips and the supply is cut off as a result of the imbalance it causes on the device's neutral coil, which verifies the RCCB's dependability.

Steps to choose an RCCB:

Generally, RCCBs are rated for sensitivity between 30mA and 300mA, where 30 mA is the best choice for household consumers. However, 30mA RCCBs are very sensitive and consumers may face some trips without any apparent fault. Considering this, 60mA or 100 mA RCCBs are installed in most of the households as it provides a balance between no apparent fault and real fault.

Advantages of RCCB

- Protects against earth faults or current leakages.
- Automated circuit disconnection on excess rated sensitivity.
- Protects against fluctuations in voltage.
- Provision of test buttons to ensure the working of the system.

Disadvantages of RCCB

- Might lead to unwanted tripping at times due to sudden electrical load changes, leading to flow of current to earth, especially in the case of older

appliances.

- Does not protect from current overload, as is designed for protection during fluctuations in live and neutral current.
- No detection of current overload.
- Does not protect from overheating due to improper conductor fittings into the terminal.

d. Residual Current Circuit Breaker with Overload protection (RCBO):

RCBOs are a combination of MCB and RCCB. It constitutes short circuit, overload and residual current protection features. High voltage due to open neutral can also be avoided.

e. Earth Leakage Circuit Breaker (ELCB):

ELCB will first detect the leakage current by measuring the voltage across the earth resistance. The function of ELCB is similar to RCCB, where RCCB is a current sensing device and ELCB is a voltage sensing device.

Note:

- *The Central Electricity Authority (Measures relating to Safety and Electricity Supply) Regulations, 2010 mandates electrical installations to be controlled by earth leakage protective devices.*
- *Several states in the country have mandated ELCB / RCCB to be installed at the premises to get a service connection.*

For example -

- *Tamil Nadu: Installation of Residual Current Device (RCD) in all electricity service connections,*
- *Assam: Installation of ELCB in electricity connections over 2kW,*
- *Delhi: Installation of ELCB for electricity connection of 5 kW and above.*

Advantages of ELCB

- It is not as sensitive to fault conditions, hence less likely to trip unnecessarily.
- Proves cheap and efficient.
- When the installation has two connections to the earth, this process will result in a voltage gradient in the soil that will provide the ELCB sense coil with enough voltage to cause it to trip.

Disadvantages of ELCB

- May fail to respond in some conditions.
- Requires a good connection to the earth in order to provide load protection.
- Because the earthing system is connected to the piping, they prevent a single building system from being easily divided into multiple portions with independent fault protection.
- Offer extra resistance and a second point of failure to a voltage that is high enough to trip the device.
- External voltage from something linked to the earthing system, like metal pipes, may trip them.

Difference between RCCB and ELCB:

S.No	RCCB	ELCB
1	It is a current sensing device	It is a voltage sensing device
2	It ensures 100% detection of leakage current & is available to sense the AC as well as DC leakage current.	It is not preferable as it can only detect current that flows back through the main earth wire.
3	RCCB has no connection with the earth wire and hence that is why it can trip when both currents (phase and neutral) are different and it withstands up to both the currents are the same.	ELCB works based on earth leakage current. These devices measured the voltage on the earth conductor; if this voltage was not zero this indicates a current leakage to earth.

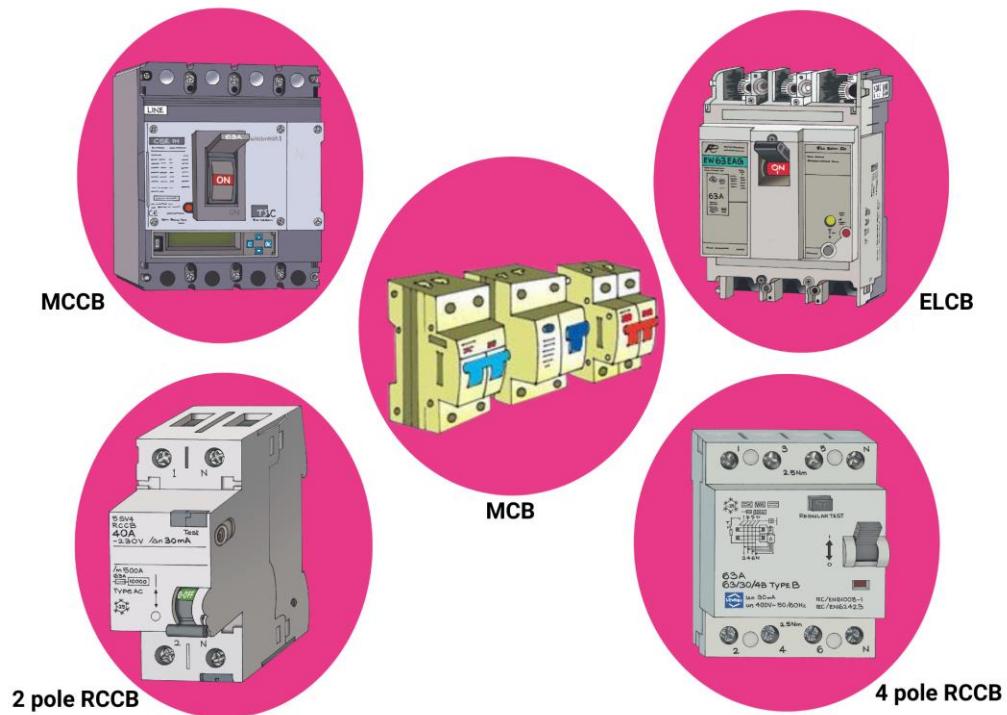


Fig 27: MCB, MCCB, RCCB, ELCB

5. Safety Plastic Caps

With safety caps, you reduce the risk of your child sticking their fingers and other objects into the wall socket. They're usually designed to be difficult to pull off (for you and your child). Installation is a simple matter of just pushing these into each outlet.

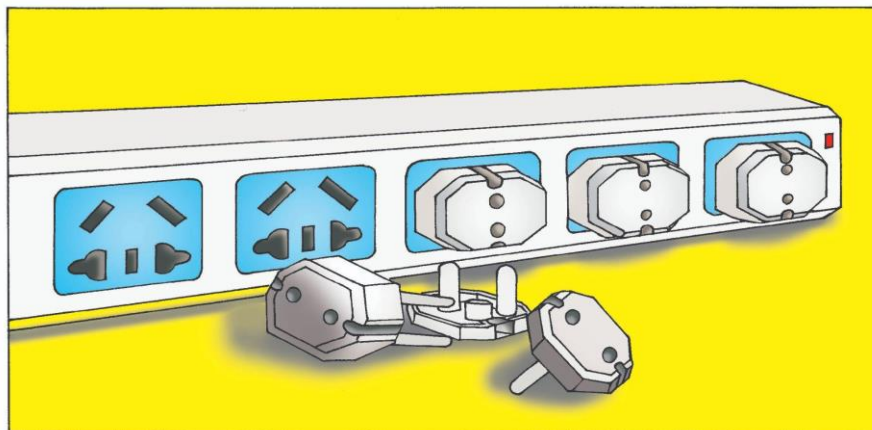


Fig 28: Plastic socket caps

6. Surge Protector: A surge protector is an electrical device that protects equipment from power surges and voltage spikes by preventing voltage from exceeding a safe level (approximately 120 V). When a voltage exceeds 120V, a surge protector shorts the electricity to the ground or blocks it. Anything higher than 120V without a surge protector can cause irreversible damage, limited device lifespan, burned wiring, and data loss.

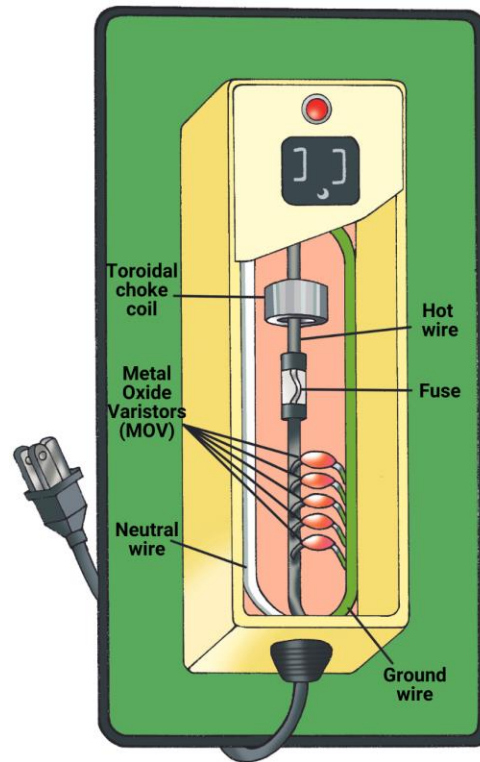


Fig 29: Surge Protector

7. Potential Areas of Damage : While an electrical problem can develop at any point in the wiring system, the following are the primary possible areas:

- Your meter room or metering box
- Distribution Box in your house/apartment/flat
- Electrical appliances with a high wattage
- Wires that are overheated
- Socket Outlets and lighting fixtures

8. Cautionary Signs:

Overlooking the electrical malfunctions at your house is generally the cause of accidents that severely damage life and property. These malfunctions could be

caused due to poor house wiring, overloading, faulty power grip, uncovered junction box, over circuited panel, etc leading to frequent electric shocks, power outages, burning out of lights, high electricity bill, etc

Signals to take care of, as soon as you observe such instances at your premises, are listed as under:

- Frequently tripping of MCB or giving sparks during operating.
- Lights that flicker often.
- Wires getting overheated quickly, discolored switch plates or outlet covers(may not be usually seen).
- Appliances giving electrical shocks – even mild ones.
- Damaged insulation cover of the wire(may not be usually visible).

9. Electrical Maintenance and Safety Tips:

While there are many aspects in the electrical system that are to be attended only by an electrician, there are a few electrical safety measures that every individual should follow.

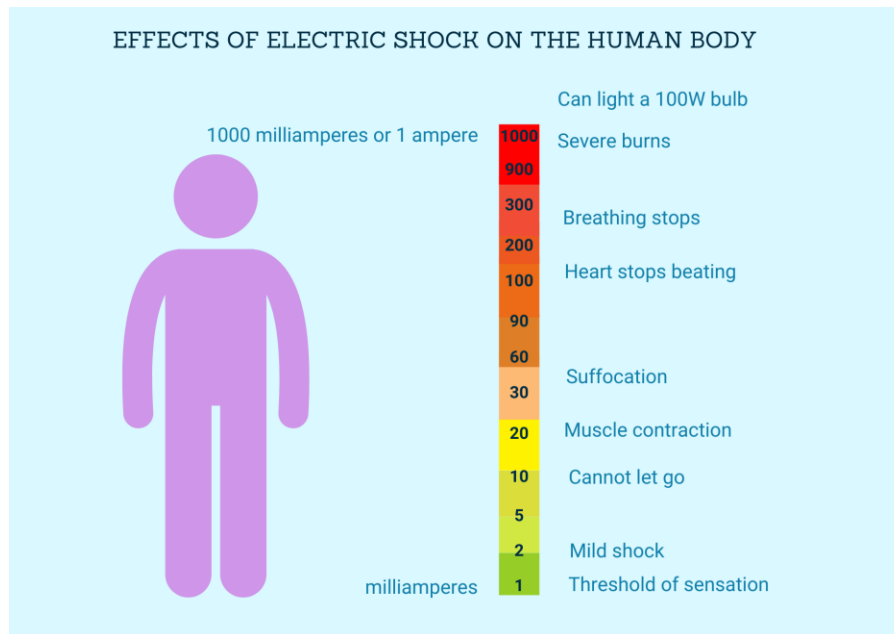


Fig 30: Severity Impact

These measures are:

1. It is advisable to install safety devices as mentioned in the chapter , to avoid electrical mishaps.
2. Keep switch/socket boards out of children's reach and place safety caps on all unused electrical outlets.
3. Check, with the help of licensed technical personnel, if your home's earthing

system is in good working order.

4. In moist regions, do not use any electrical appliances or operate switches or sockets with bare feet. Keep in mind that water and electricity are a lethal mix.
5. Avoid placing any electrical outlets near showers, bathtubs, sinks, or damp places.
6. As far as possible do not use any electrical appliances during thunderstorms, high winds, or rain; instead, turn them off.
7. Use ISI-marked electrical products at all times.
8. Do not plug several items (sockets/instruments) into the same outlet or extension cord.
9. Do not use force to remove an electrical cord from a socket board.
10. Make certain that all electrical cords are neatly tucked away.
11. Have a professional home inspection of your home done on a regular basis, mainly to ensure electrical safety.

10. Installation and Maintenance of electrical wiring

Proper care is to be taken during the wiring of the systems. The following points should be considered during the installation of wiring:

1. Proper size of wires to be used for different types of equipment.
2. Different phase circuits should not be run through the same conduits. Separate conduits to be used for drawing different phase circuits.
3. Wire joints are to be made only in switch boxes or fittings.
4. There should not be any wire joints inside the conduits.
5. The conduits should not be crowded with wires. Only a specified number of wires should be drawn through specified sizes of conduits. Eg: Maximum 9 numbers of 2.5 sq. mm wires only should be drawn through a 1-inch conduit. Maximum 6 numbers of 2.5 sq. mm wires only should be drawn through ¾" conduit.
6. Correct color-coded wires to be used for wiring, for maintaining wiring uniformity and to identify them easily.
7. Separate Phase, Neutral and Earth wires should be used for individual circuits in wiring. Neutral or Earth wires should not be looped for multiple circuits.
8. Maximum 10 lights or 800 Watts power only to be connected to a single lighting circuit.
9. All the connecting points should be made properly and with correct tightness

in all electrical equipment/appliances to avoid future loose connections and further short circuits in equipment /appliances.

10. The same standards are to be followed during any additions or repair work in electrical wiring.

11. There is no other maintenance to be done for wiring if the installations/repairs/alterations are done properly.

11. Checklist for safe electrical installation

- All wiring was carried out by a competent electrician.
- Circuit Breaker or a suitable fuse installed
- Correct installation of earthing wires.
- Regular repairs and maintenance.
- Overloading inspection.
- No hanging cables or wires on the ground.
- Plugs fulfill the standard mark or specification.
- Dry environment near the electric workplace.
- Flammable items kept away from electrical appliances.
- Proper ventilation.
- Waterproof cables and plugs are used.
- Checking for signs of cable or appliance overheating.
- Fire extinguishers are placed next to places vulnerable to fire hazards.
- Non-conducting material support systems like wooden ladders are to be used while repairs and checks.

12. Electrical Hazards and Ways to Rescue

Electrical dangers are broadly classified into three types -

i)electrical shock, ii)electrical burns, and iii)blast consequences like flying particles from vaporized conductors, pressure impact and first breath issues .

An electric current travelling through the body causes an electric shock accident. A shock can cause anything from tingling to abrupt death. Knowing what to do in the event of an electrical shock could mean the difference between life and death. Steps to rescue a victim are as follows:

Step 1 : *Examine the scene of the incident thoroughly.* Rushing in to help someone may be your natural instinct, but if the risk of electrical shock remains, you will only endanger yourself. Take time to evaluate the situation and check for any

evident threats.

Investigate the cause of the electrical shock. Examine whether the victim is still in contact with the source. Don't touch them since electricity can pass through the victim to you.

If there is a fire, NEVER use water since water is a good conductor of electricity. If the floor is damp, NEVER enter an area where electrical equipment is used. Make use of an electrical fire extinguisher. Electrical fire extinguishers will be labelled as such: C, BC, or ABC extinguisher.

Step 2 : Contact emergency services. It is critical that you call for assistance as soon as possible. The sooner you call, the faster assistance will arrive. When you make the call, explain your issue as gently and simply as possible.

Explain that the situation involves an electrical shock so that the first responders are properly prepared.

Try not to be alarmed. Maintaining as much calm as possible can assist you in relaying the correct information.

Speak loudly. Emergency services will want precise and unambiguous information. Speaking too hastily may result in misunderstanding, wasting valuable time.

Please provide your correct address and phone number.

Majority of the countries have made emergency service phone numbers easy to remember. For eg India: 112

Step 3: Turn off the power. Turn off the electricity if you can do so safely. Don't try to save someone who is near a high-voltage line. The preferred method is to turn off the power at the power box, circuit breaker, or fuse box. To switch off the power with a circuit breaker box, follow these steps:

- Remove the breaker from the circuit breaker box. At the top of the fuse box, look for a rectangular block with a handle.
- Take hold of the handle and flip it to the opposite side, exactly like a light switch.
- To double-check that the power is turned off, turn on a lamp or other electrical device.

Step 4: Remove the victim from the source. If the electricity hasn't been turned off, don't touch the victim, even with non-conducting equipment. Once you're certain there's no current, distance the victim from the source with a rubber or wooden stick or any other non-conducting object. Glass, porcelain, plastic, and paper are examples of non-conducting materials. You can also use cardboard, which is a typical non-conducting material.

Copper, aluminum, gold, and silver are examples of conductors, which allow electricity to flow.

If a lightning has struck the victim, they are safe to touch.

For Treating Burns:

Step 1: Anyone who has had a minor burn as a result of an electrical shock will require medical attention. You should not try to treat the sufferer on your own. Contact emergency services.

Step 2: *Determine the burned regions.* Burn wounds have distinct characteristics that can aid in their identification. Look for any injuries on the victim that exhibit one or more of the following characteristics:

- Skin that is red
- Skin peeling
- Swelling
- Blisters
- a gleaming appearance
- Skin that is charred (white, brown, or black)

Step 3: *Rinse the burn.* Electricity normally enters the body in one location and exits in another. Examine the victim as much as possible. After determining the extent of the injury, clean the burns with cool water. To avoid bacterial infection, make sure the water is clean. Use no ice, cold or hot water, creams, or oily drinks on the burn. Burned skin is susceptible to high temperatures, and lotions may impede healing.

Step 4: Cover the burn and wait for emergency services. Covering the burn can help prevent it from further harm and will reduce the danger of infection. Use non-adhesive sterile bandages or clean cloths.

Chapter 9

Earthing and bonding

Earthing and bonding are essential for every electrical installation to ensure safety and safeguard from any electrical faults and accidents. Electricians, before working on the electrical installations, must check the earthing and bonding arrangements to confirm its safety.

As per the Indian Standard Code of Practice for Earthing - IS 3043 : 1987, the terms earth, earthing, and earth electrodes all have various meanings. Earth is the general mass of planet earth, whereas an earth electrode is a separate system built to offer an electrical connection to earth (ground/soil). Earthing is a complex network that connects all exposed conductive portions of any equipment or installation to earth potential via MET (Main Earthing Terminal).

Similarly, grounding and earthing are nearly synonymous terms that refer to connecting an electrical item to the ground (earth plate or earth electrode through continuity conductor or protective rod). This system provides a necessary reference voltage in the circuit to protect the installations from lightning strikes and to discharge the fault current to the earth, thereby protecting lives. The table below distinguishes between grounding, earthing, and bonding.

Components of Electrical Earthing System

Following are the main components of the Electrical Earthing System:

- **Earth Continuity Conductor:** Commonly referred to as the Earth Cable, mostly green in color, it connects all metallic parts of an electrical installation, such as the conduit, metallic shells, ducts, plug sockets, distribution boxes, fuses, controlling and regulating devices, metallic parts of transformers, motors, generators, and so on, as well as the metallic framework where the electrical components are installed. Its resistance i.e, opposition to current flow must be very low.
- **Earthing Lead or joint:** The conductor that connects the earth continuity conductor and the earth electrode is known as the earthing lead or earthing junction. The connection point is where the earthing lead and the earth continuity conductor meet. It must be straight, small in size, and have a

minimum number of joints. Although copper wires are commonly used as earthing leads, copper strips are chosen for high installation because they can carry higher values of fault current due to their larger area. Hard pulled bare copper wires are also utilized as earthing leads.

- **Earth Electrode or Earth plate:** It's the final component of the earthing system that is buried underground and connected to the earthing lead. It can take the form of a metallic rod, pipe, or plate with very low resistance in order to safely transfer the fault current to the ground. It could be made of copper or galvanized iron and should be buried in moist ground, and if the moisture content of the earth is low, water should be added to the galvanised iron earth electrode. It is always positioned vertically, surrounded by layers of charcoal, lime, and salt. This increases its size while also keeping moisture around. It must be at least 4 metres long for effective earthing action.

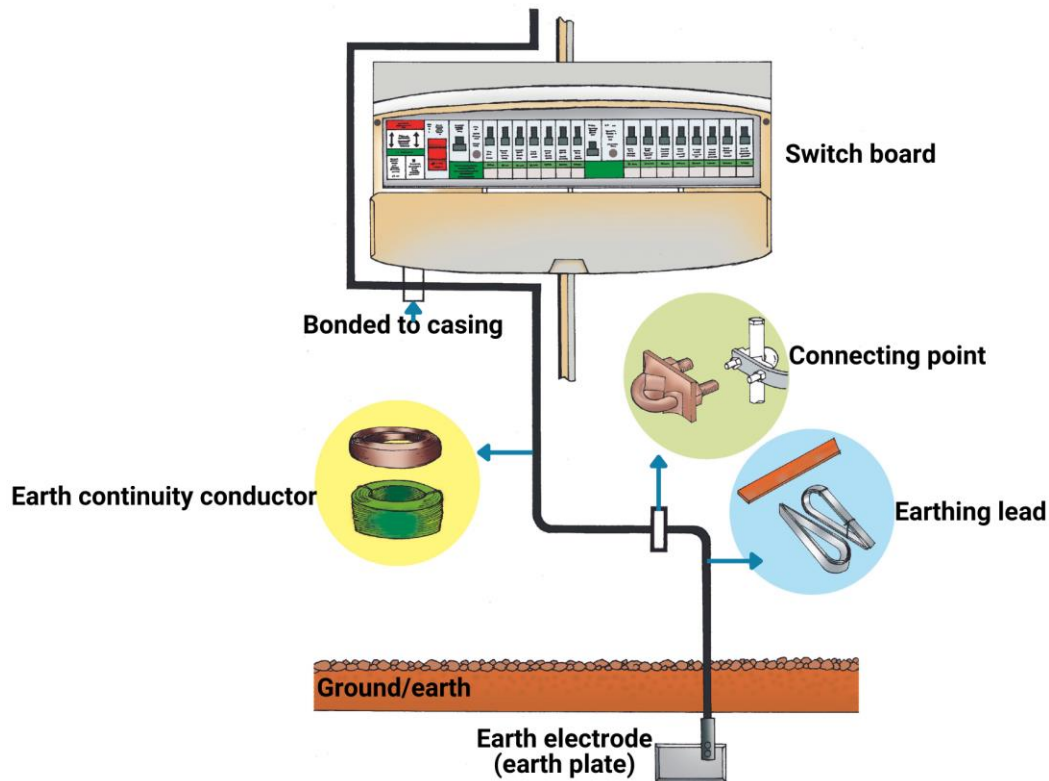




Fig 31: Components of Earthing System

Characteristics	Earthing	Bonding
Symbol		
Definition	Involves connecting the metallic (conductive) parts (such as the body, frame which is non-current carrying during normal operation) of an electric appliance or installation to the earth (ground) is called Earthing.	It connects two electrical systems (such as wires, equipment, pipes, etc) together to bring them to the same potential level while they are non-current carrying during the normal operation.
Location of Installation	Connection between the metallic body frame and earth plate in the ground through earth continuity conductor & earthing lead.	Connection between two equipment, wires, pipes, etc which are non-current carrying during normal operation through a conductor.
Types	Pipe earthing, plate earthing, water main earthing, Rod earthing & stripe wire earthing.	Main bonding and supplementary bonding.
Wire Color Code	Green or green with yellow stripe or bare conductor.	Green with a yellow stripe.

Path	Provides a path to a large surface to zero volt potential.	Provides a path to equalize the potential difference on two different surceases.
“0” Potential	Zero potential due to the physical connection between equipment and ground.	Same and zero electrical potential on both connected devices.
Protection	It protects a person from hazardous electric shock as it is a preventive measure to discharge unwanted electrical energy to the ground.	It protects equipment and personnel by reducing the current flow between two machines having different potentials. the Bonding itself does not protect anything without earthing
Examples	The metallic body frame and enclosure of the electrical machines (transformer, motors, generators etc) connected to the earth electrode (earth plate).	Any conductor wire connected between two metallic bodies of the electrical machines & devices to equalize the potential difference on them.
Usage	It is used to provide protection against both electric shock and faults in the system.	It is used to trip the circuit breaker when high current flows due to the existence/change in the positional difference.

Applications	Earthing draws unwanted energy to the ground to protect the person who touches the metallic body of the machine during faults.	Bonding ensures both the connected devices at the same level of voltage and provides a low impedance path back to the source to trip the CB in case of fault currents.
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Consider the two cases below in Figures 2A and 2B, which are fed by two different power systems (low voltage and medium voltage) and are connected to separate earths.

Consider the following scenario: a person standing on earth but perfectly insulated from the earth and simultaneously touching both the motors. If an earth fault occurs at one of the motors, the motor body will spring to life and the individual will experience a shock.

If we connect both motor bodies and connect them to the earth, the potential difference generated on one motor body due to the earth's fault will be the same on the other body due to interconnection.

Thus, the motor's metal exterior may become "live" if there was no earth connection. By reducing the duration of contact voltages, earthing works to avoid situations like this one. On the other hand, all metallic components are connected through bonding, utilising a securing bonding conductor.

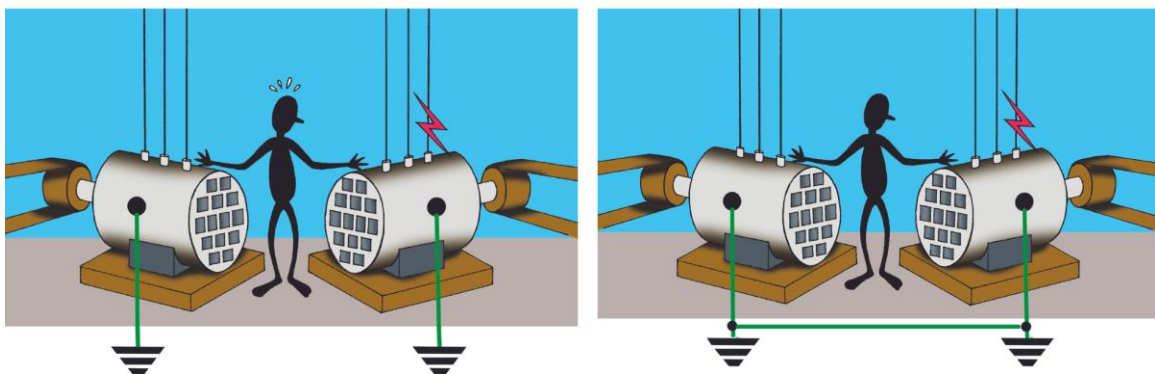


Figure 2A

Figure 2B

Fig 32: No Bonding and Bonding

Earthing/Grounding

The prime objective of electrical safety is to prevent electrical hazards, primarily to the human body and secondarily to other equipment. This could be achieved by diverting the fault currents to the earth by providing proper earthing or grounding. It simply involves the connection of the body of all electrical equipment, devices, and their metallic parts to the ground with the help of a thick conductive wire. By doing so, the excess current flowing in the circuit due to an electrical short circuit, lightning or electrical surge, can be directed to the ground. Thus it ensures safety, and avoids electrocution and electrical fires to the building. It also helps in protecting the appliances from damage due to short circuits.

In addition to the above, all the protective devices in the electrical circuit such as earth leak protections, MCBs, etc will function properly only if there is proper earthing provided to the types of equipment.

The main distinction between earthing and grounding is that "earthing" implies that the circuit is physically connected to the ground, which has a zero voltage potential (Earth). The circuit is not physically connected to the ground in "grounding," but its potential is zero in relation to other places.

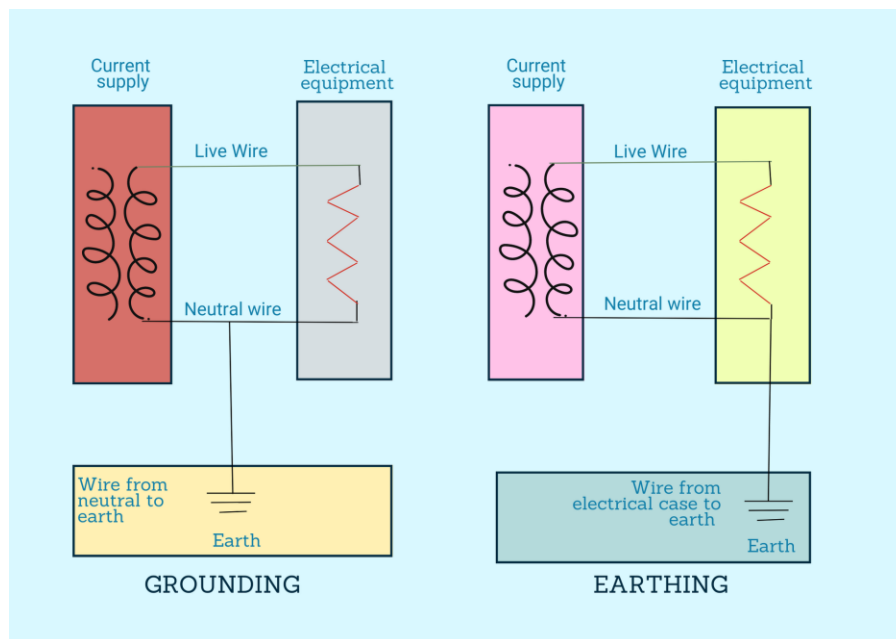


Fig 33: Earthing Vs Grounding

How to Check Earthing at home

1. Take a 100-watt standard lightbulb. Ask your local hardware store for a standalone base socket made to use with 100-watt light bulbs, with two wires already attached to it. If the power rating of the bulbs is too low or high then the test may not work.
2. Using a pair of wire strippers(or scissors), find the corresponding gauge for the wire on the base. Clamp one of the wires in the slot such that it protrudes about 12 inches (1.3 cm) from the opposite side. Pull the wire slowly toward you to cut through the insulation and strip it, exposing the wiring. Repeat for the second wire on the opposite side of the base.
3. Purchase a plug that works with the wiring of your lamp. Check to see if the cord on your plug is flat. If so, you must purchase a wire plug in the clamp style. However, you must buy a two-pronged wire plug if it is spherical. Visit your neighbourhood hardware store to learn more about your alternatives.
4. To begin with, remove both cables from their respective ports. Place one of the wires in the earthing port, which is the third hole on the top or bottom of your outlet. Reconnect the second wire to the live port and check to see if the lamp glows. If the lightbulb has the same intensity as the previous test, the outlet has been properly earthed. If the light does not turn on at all, the outlet is not earthed.

If the light is dimmer than it was in your initial test, your outlet has earthing, but it may be defective. To determine the root of the problem, hire an electrician to evaluate your electrical system.

Chapter 10

IoT home application

Introduction to IoT

IoT stands for Internet of Things. It is a network of interconnected systems which helps in the collection and transfer of data using a wireless network. This can be performed without much human intervention. In simple terms, IoT is connecting objects and devices to the internet.

IoT and cloud computing make it possible to control, monitor, and manage daily household activities/devices with the use of wireless communication technology. A house with some (or all) of its devices integrated with automated technology is a smart home.

The emergence of Smart Homes and the increase in their demand in the past few years signify the improvement in standards of living and the ease of living that these homes provide.

Role (or Benefits) of IoT in household electricals

Domestic appliances can be electronically controlled with the installation of IoT automation systems connected to your mobile phone, personal computer, or game console. The smart home and its integrated systems help to maintain a comfortable temperature, monitor an empty home, manage energy usage - and do all this remotely.



Fig 34: Benefits of IoT

- **Safety and security:** Internal and perimeter security are ensured by safety and security sensors. It does more than just alert you if someone is attempting to break into your home. The intrusion alarms and sirens are linked to smart door locks, thermostats, and lightbulbs via your Wi-Fi network. These devices can communicate with one another and with your security system if they are connected, making your life easier and safer.
- **Provides precise monitoring:** for the prevention of potential hazards such as flooding and fire.
- **Managing utilities:** Smart homes have connected monitors that help you save money on electricity and water. For instance, when the water tank is full, the sensors automatically turn off the motor.
- **Monitor one's health:** Wearables are devices that are attached to a patient's body and provide health information as well as monitor chronic conditions such as diabetes or Alzheimer's.
- **Personalises entertainment tasks:** smart video and music players adapting to the preferences of the user.

Common household IoT devices

- **Smart Light Bulbs -** The majority of smart bulbs are connected to a hub, which is simply a collection of hardware. These are simple to install and are less expensive than other smart home upgrades such as security monitors.

These LEDs can save up to six times the energy of incandescent lighting. The hub and the app (which controls the bulbs) will guide you through the installation process and provide you with a wide range of lighting options. Switching to these bulbs is cost-effective in the long run because they can last for over 25,000 hours of use. These not only provide color adjustments for different mood settings but also dim and brighten the light as per the time of the day.

- **Smart Speakers** - These devices, which are controlled by AI-powered intelligent personal assistants, can provide information on everything from traffic conditions to recipes. They can also help you with financial management, from checking account balances to making bill payments using simply your voice commands. The most well-known smart speakers are Amazon Echo and Google Home.
- **Smart Refrigerators** - It use a smart mechanism to detect the items stored in the fridge, and their expiration timeline (the details of products are entered manually or labelled via barcode in the system). The camera inside it enables you to look up all the items stored inside, saving energy loss on the frequent opening of the fridge, as well as alerting you to food items that will expire soon. Some of these are compatible with virtual assistants like Google Assistant or Amazon Alexa. Remotely accessible by all family members who can see the notes and reminders if any.
- **Smart Plug** - It is an IoT-based device used to make an ordinary device/appliance into a smart one. You can plug the smart plug into your electrical socket and then any appliance to be remotely controlled. In order to decide the type of smart plug, look into the load capacity required by you for supporting your device. Some plugs cannot manage the amount of power that appliances like air conditioners, refrigerators, washers, and dryers draw. Check the specifications of a smart plug before purchasing.
 - It supports appliances which function directly with on and off switches. Thus, coffee makers or other appliances which need you to push the button for 'hot' or 'cold' features might not be supported by this plug.
 - These are heavy and thick. You might not be able to fit anything else into your second socket if your smart plug is using one of the sockets. Measure before you buy and read user evaluations, as you can generally find dimensions on the company or retailer's website.
 - Smart plugs are available at 10 A and 16 A rated capacity. For heavy appliances like air conditioners, water heaters, a consumer must use a 16 A

smart plug. For other appliances like lights, fans, mobile chargers etc, consumers can select 10 A smart plugs.

- These are operated using an app, which on installation gives you various access options. To make operations easier, make sure to buy all the smart plugs from the same manufacturer in case multiple plugs are to be used.
- These also work with Google Assistant or Alexa, so you may not need to use the app once you've set it up and connected it to your voice assistant.
- You may need to reconnect your smart plug if your Wi-Fi or power goes off. When the power is restored, some plugs immediately restore to the previous setting.
- **Smart Strip** - Stand-by power loss (where devices continue using electricity even when turned off), is by now, a well known phenomenon. Smart strips help to solve this problem. Turning off individual devices that work around one central instrument (for example, the DVD player, game console and speakers that all work around the TV) can be a tedious job. Smart Strips sense when the TV is turned off, in turn, switching off the other instruments connected to it.
- **2 or 4-channel relay** - The 2 Channels Relay Module is a handy board for controlling high voltage, high current loads such as motors, solenoid valves, lamps, and AC loads. It also has an LED that shows the state of the relay.

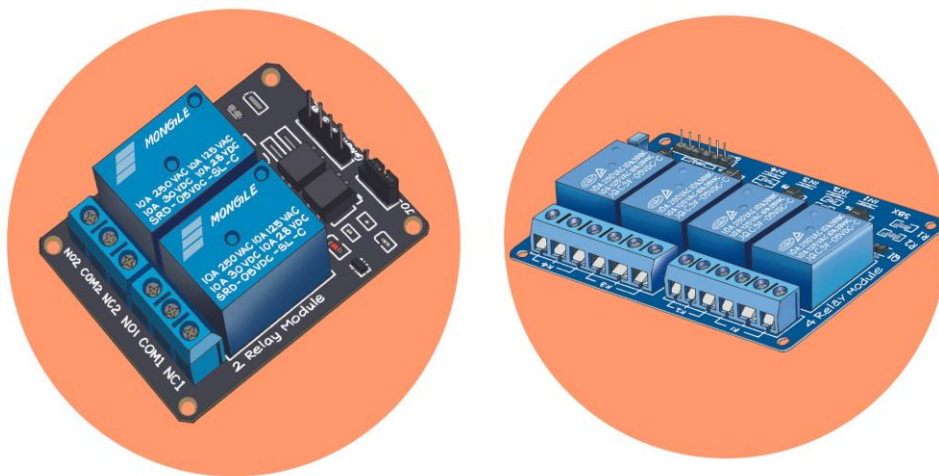


Fig 35: 2 and 4 channel relay

- **IR Blast** - An IR blaster connects your remote to your entertainment device in the same way that an IR remote control does. You must first pair the IR blaster with your smart TV system and any other devices you want to control in order for it to work.

One of the many advantages of IR blasters is that they don't require direct contact with your TV system to operate. Only the IR blasters and the hub to which they're linked must be near your smart TV system. You can now control your TV and other smart home gadgets simultaneously.

- **Smart Locks** - Uses IoT-enabled sensors to control keyless entry devices, allowing users to unlock doors from anywhere using a smartphone or other internet-connected device. Smart locks allow users to unlock their doors without a key, from anywhere and distribute virtual keys to visitors. It can be integrated with other IoT devices, smart assistants, or smart home management systems to provide additional functionality. When the door is unlocked, these functions can include automating processes such as turning on lights and adjusting the thermostat, or triggering the security system to record and send video if the door is unlocked.
- **Energy Monitoring System (EMS)** - Most consumers look at the 'monthly' bill amount to be paid and make the payment without actively participating in monitoring their energy consumption patterns. Smart home energy monitoring systems monitor and observe 'minute-by-minute' trends in energy consumption at home through Wi-fi connectivity. These systems are either connected to the electrical panel or the meter in your home. They act as a communication point for homeowners, appliances, and devices, as well as the distribution company sometimes. You can easily check your energy use patterns on the screen of your smartphone/laptop or computer device.

Apart from this, the EMS aids in automatic power factor correcting. Power Factor of a load is the ratio of Active Power (kW) to Apparent Power (kVA) of an electrical system. It basically measures how effectively the electric power is consumed by the load to give useful power output. A pf greater than equal to 0.95 is considered desirable for efficient output. The automated microcontroller in EMS makes sure to correct your pf if it is less than 0.95.
- **Smart Meter** - Smart meter is an IoT device that monitors and transmits data on energy, water, and gas usage. It shares information directly from utility meters using connected sensors, eliminating the need for providers to manually check installations in order to charge users and manage infrastructure. Some smart meter gateways can even connect to building automation systems, allowing users to control heating, cooling, and other utilities in their houses, based on usage.

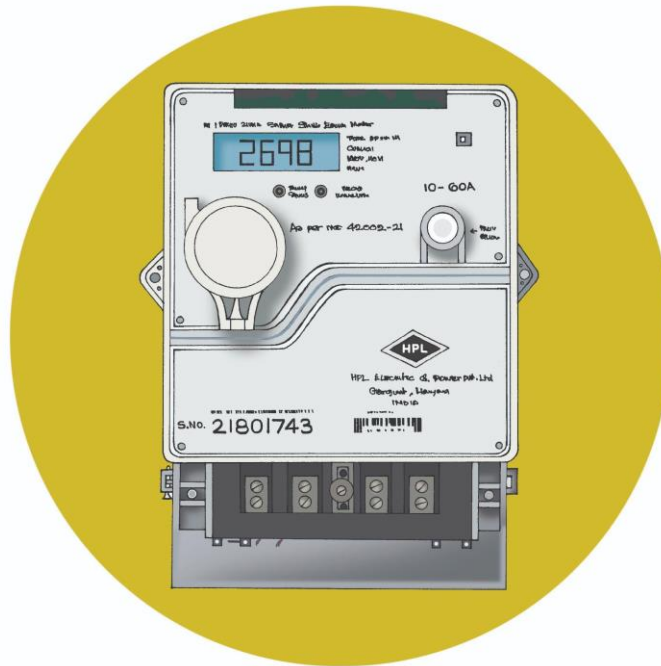


Fig 36: Smart Meter

- **Smart Water Management System** - Real-time monitoring, a data-driven approach, and an immediate alert system are all advantages of sensors in the water use management process.

Did you know?

Bathing and toileting account for about 27% of our total water consumption. In a leaking faucet, 4000 drips equals one liter of water wasted.

Thus, a smart water management system lets you measure the amount of water wasted with the help of IoT-powered solutions and receive instant notifications as soon as the water begins to leak.. IoT-izing the water sector helps to keep track of consumption patterns and thus ensures that our natural resources are conserved effectively.

Advantages of IoT

- **Energy-saving helps to lead a greener lifestyle:** You can program your smart home automation system in a way that turns off the devices when not in use. It will send you a notification if it malfunctions, allowing you to schedule maintenance before it becomes too late. Although the cost of implementing IoT technology at home is high, it will eventually save you money. It is also advantageous in terms of environmental conservation.
- **IoT provides security to the property:** Not only can you close your main

doors and entrances with your mobile phones sitting in your office but in case of a smoke situation, the smoke detectors alert other devices thus preventing its spread along with activating a water sprinkler system to avoid fire.

- **Ease of Parental Control:** You can set a screen time limit for your children so that they can watch the screen only for a fixed time period. You can also set a channel limit on your Smart TV device to keep your children away from inappropriate content.
- **Gives comfort and a convenient way of living:** It allows you to control home appliances, such as your smart coffee maker, according to your schedule. When you get home from work in the morning and evening, it will automatically start brewing coffee. You can control not only the kitchen device but also the entertainment device. If you always listen to soothing music while sleeping, the smart home system will turn it on automatically, and the music player will turn off after a specified amount of time. There are a plethora of other examples.

Disadvantages of IoT

- If a tube light which has multiple color lumens, is connected with a power backup facility like an inverter, then in case of a power cut and power being restored, the color lumens of the tubelights will be changed during the power interruption period.
- There are some chances, where the online monitoring applications may not show the power cut. For example, if an air conditioner (AC) which can be controlled by the IR Blast is not connected to the power back up facility but the IR Blast and wifi are connected to the respective sockets, those sockets are also connected to power backup facility then in case of power cut, IR Blast will be shown as “online or available” in the mobile application. However the AC cannot be controlled since AC does not receive the power.
- **Installation costs are high** - Significant costs can be incurred on installation depending on the quality of the system though it brings energy savings in the long run.
- **Stable internet connection is a must** - If you live in an area where the internet connection is poor, for example, you may have serious problems because your smart home devices may not respond as you expect.
- **Concerns about security** - There's a possibility of hackers hacking into your system which might lead to data theft and privacy violation.
- **Problems with technology in connected homes** - If there are issues with the

connection between your smartphone and your household devices, you will most likely lose control of your smart home device.

- **You might find yourself locked out of your own home** - For example, if the voice system is unable to recognise your voice, you may be denied access to your home and must instead hire a professional to open your door, which can be quite costly.
- **Smart technologies may irritate some people** - The older generation, in particular, is frequently skeptical.
- **Issues with maintenance and repair** - Many handymen are not yet qualified in this field, and finding an expert to repair smart home technological devices may be difficult.
- **Initial learning efforts are required** - you'll need to equip yourself to operate the entire housing appliance system on your devices.
- **Problems with device compatibility** - use of different apps for various devices might make it difficult for different devices to connect.
- **Surges may occur** - If your home is not properly protected, fires are more likely to occur, and in the worst-case scenario, your home may burn down due to the simultaneous use of too many smart household devices. The likelihood of malfunctioning smart device operations increases with the complexity of the home. An ecosystem of interconnectedness is created by smart home appliances, and if something goes wrong, this ecosystem could have a cascading effect. Every smart device is also connected to the house's electrical system and has the capacity to start a fire on its own.
- **Suitability:** Smart home technology isn't appropriate for every home (as homes allowing access to unhindered internet connectivity is a must and remote locations with improper or lack of internet connectivity might suffer).
- **Obsolescence** - Technology may become obsolete in the near future. (as a result, it is advisable to run the latest software updates available for your old device or buy a new device supporting the latest technology).

Maintenance of Smart Home Devices

Checking and monitoring your network, as well as ensuring your security through periodic inspection and, of course, updating outdated devices, are the key to proper maintenance.

Because smart homes rely on a network of automated smart devices, it's critical that these devices work correctly and without error.

- 1) **Software updated devices** - What should you look for during your inspection?
The first step is to ensure that your smart home-connected devices have the most recent software updates. Manufacturers of smart home devices will send out these updates on a regular basis. It is also critical to ensure that your hardware is up to date. If it isn't, it's probably time to upgrade your old smart device.
- 2) **Routine Checks** - Smart devices can be used to monitor these functions on a daily basis say, electricity usage checked, using smart meters. Though these are automated functions, it is still necessary to check and calibrate them on a regular basis to ensure that they are working properly.
- 3) **Maintaining the ability to connect** - Your network is essential for your smart home. Your devices' ability to connect would be lost without it. It's just as crucial to keep your network router up to date and in good working order. Periodic diagnostics can assist in achieving this goal. Smart home support is made possible by internet home automation.
- 4) **Upgraded Devices** - smart security devices should be maintained, updated, and upgraded whenever possible. Pay extra close attention when inspecting and checking these devices because security isn't something to be taken for granted.

Chapter 11

Renewable energy

Understanding the difference between energy sources

Energy is an indispensable part of our lives. Awareness of where your home appliances source energy from and the various green alternatives available, promotes wise use.

- *Renewable energy*, also called clean energy, is obtained from sources that replace naturally and cannot run out, like heat energy from the sun. These resources are unlimited in supply and can be used as alternatives to fossil fuels. For example, solar energy, wind energy etc.
- *Non-renewable energy* is obtained from burning fossil fuels, which take millions of years to replenish. They pollute the environment and thus are not eco-friendly. For example, burning coal or wood for cooking releases gases (like carbon dioxide and nitrogen oxide) that absorb heat and cause global warming.
- Pollution from the burning of fossil fuels can also lead to severe health conditions like asthma, lung disease, etc.

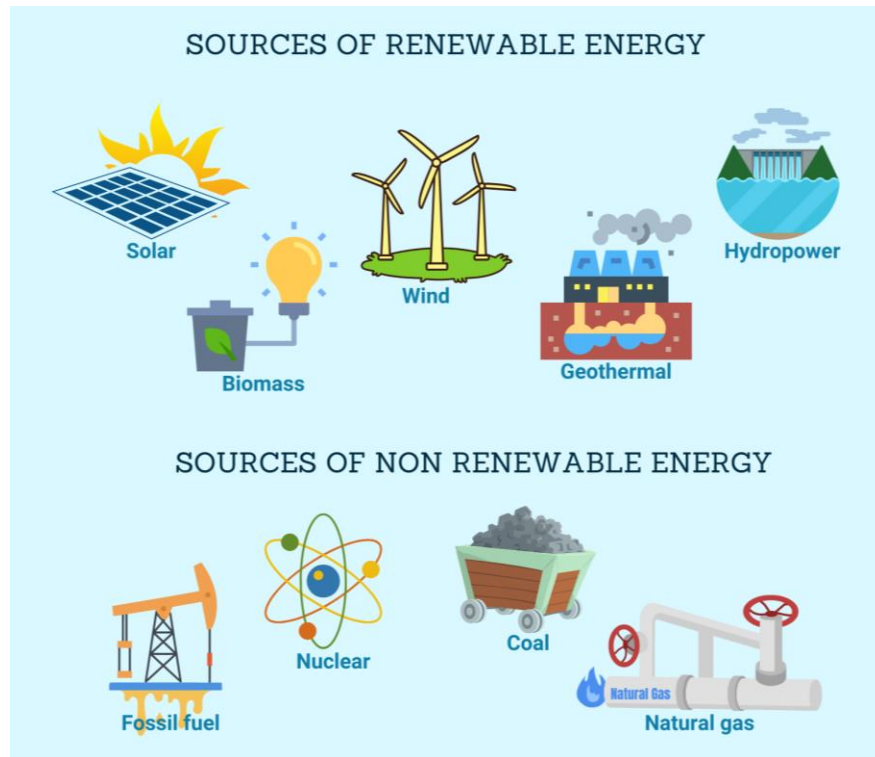


Fig 37: Renewable Energy Sources Vs Conventional Energy Sources

Importance of Renewable Energy

- Available in abundance and hence can cater to our day-to-day energy consumption demands. For example, solar energy available from the sun in one hour exceeds the total amount of energy utilized on earth in a year.
- South India is blessed with full sunshine days; thus power generation as high as 4-7 units per sq.m per day from the solar rooftop can be achieved.
- Efficient and pollution-free source of power generation for homes and buildings.
- Though the initial installations require considerable investment, it is a free source of energy in the long term.
- Helps in securing a healthy future for all habitats on earth.

Benefits of Renewable Energy

- Independent from fuel or coal price fluctuations.
- Very low operational and maintenance costs.
- Its widespread use can help in replacing thermal power plants (a major source of greenhouse gas emissions) in the near future.

Household renewables:

Common household energy-intensive appliances like water heaters, air conditioners, motors etc are powered through grid-connected electricity, the majority of the mix being generated by fossil fuels in India. Grid-connected electricity is linked with regular fuel price hikes, apart from also being a major source of pollution. Switching to renewable energy like solar energy for household purposes helps cut down on electricity bills. Presently, the solar rooftop system is an existing source of power supply. It can be used in multiple ways to generate electricity as well as produce thermal energy. To promote clean energy and set up citizens' own power generation at home, the government incentivises solar installation in residential homes (individual homes and large apartments) through subsidies. (These subsidies are not available for commercial or industrial properties.) As installing a solar system is expensive, financial aid encourages its use and relieves part of the financial burden. Only Grid Connected Solar Systems (Without Battery systems) are eligible for a solar subsidy. As per the latest order, the Ministry of New and Renewable Energy (MNRE) has informed that "Residential owners can claim the subsidy from the Government of India (GOI) through their DISCOMS."

The following section gives an in-depth understanding of the two most widely used household renewable systems namely:

- A. Solar Water Heater
- B. Solar Rooftop Photovoltaic System

Solar Water Heater:

It is a system that uses infrared or heat radiations from sunlight to heat water for various household purposes like bathing, cleaning, cooking, etc. It is currently the greenest alternative to electric or gas heaters.

Benefits

- Zero operation cost.
- Continuous hot water supply.
- Functions even during no sunshine days.
- The heaters are available in a wide range of capacities such as 100, 200, 250, and 500 LPD (Liters Per Day).

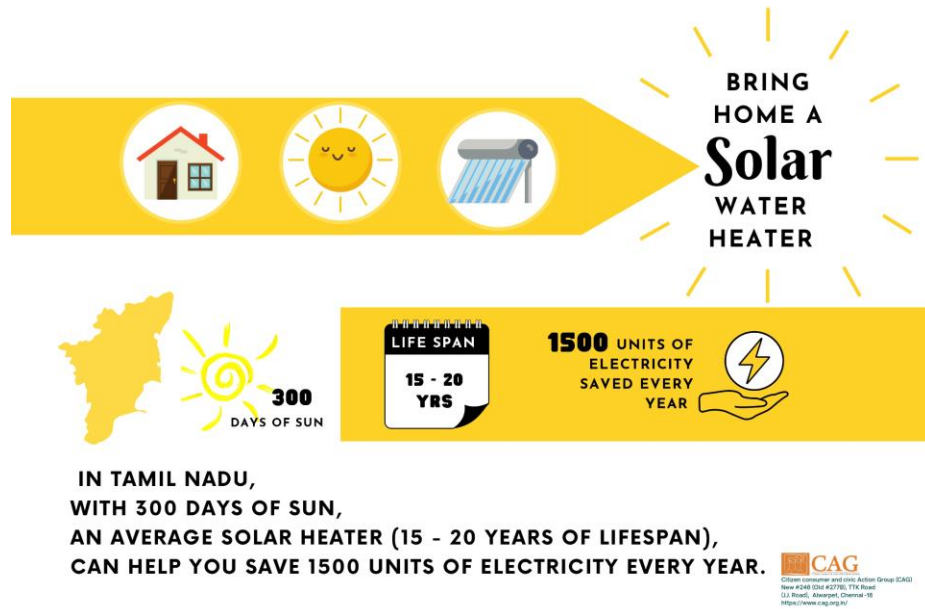


Fig 38: Benefit of solar water heater with respect to Tamil Nadu’s weather conditions.

Two technologies are domestically used to heat water in solar water heaters namely:

- Solar Evacuated Tube Collector
- Solar Flat Plate Collectors

Components of solar Evacuated Tube collector water heater

1. **Evacuated Tubes:** Converts solar energy into usable heat. The vacuum between the two glass layers acts as an insulator against heat loss.
2. **Copper Heat Pipe:** Transfers the heat from within evacuated tubes.
3. **Storage Tank:** Collects the water heated through the process.
4. **Mounting Frame:** Provides support to the system.

Working of a Solar Evacuated Tube Collector water heater

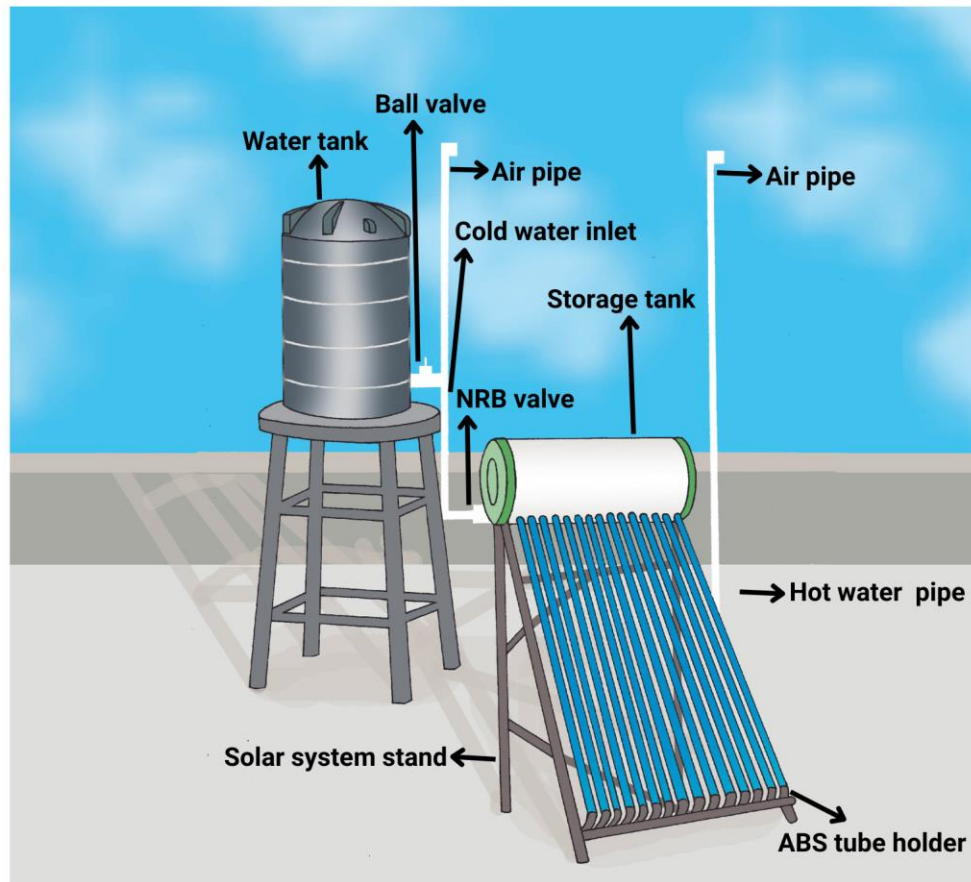


Fig 39: Evacuated Tubes Solar Heater and Components

As shown in the above figure,

1. Cold water passes through the tubes and infrared solar radiation heats the tubes.
2. The heated tubes transfer thermal energy to the water by conduction (transfer of heat among objects with direct contact) and convection (transfer of heat within matters through the movement of molecules) mode.
3. Heated water becomes lighter and is pushed by the cold water flowing into the tubes from the water tank.
4. Hot water gets collected in the storage tank. This cycle can be repeated till a certain temperature is achieved.

Components of Solar Flat Plate collector water heater

1. **Glazing or Glass Cover:** Toughened glass (glazing) protects the absorber from the outside environment while allowing >90% of sunlight to pass through.
2. **Solar Absorber:** A thin sheet of aluminium (coated with specific materials) absorbs sunlight and converts it into usable heat. The copper riser pipes are ultrasonically welded to the aluminium sheet.
3. **Insulation:** The insulation helps to reduce heat loss from the collector's sides and back. This material, made of ultra-lightweight melamine foam, was chosen to significantly reduce the weight of the collector.
4. **Back Sheet:** An aluminium alloy sheet seals the back of the panel and increases the collector's rigidity.
5. **Riser and Head Pipes:** The header and riser pipes are joined together to form a harp-shaped heat exchanger through which the heat transfer fluid from the solar system circulates. The absorber sheet is ultrasonically welded to the riser pipes, which allows heat to be transferred to the heat transfer fluid.
6. **Aluminium Rails:** provide an easy mounting structure.

Working of Solar Flat Plate Collector

- In a solar flat plate collector, a dark black flat plate traps the maximum of the sun's energy as per its capacity further transferring it to air, water or other fluids.
- It works in the following way:
 - The dark black plate absorbs the incident solar energy.
 - A glazing cover transfers the radiation to the absorber preventing any heat loss from the surface.
 - Tubes transfer the heating fluid from the collector.
 - A support structure holds the components in place.

Solar Water Heater Capacity Calculation:

The hot water from the solar heating system involves many household applications. Thus, the thumb rule for determining the right size of storage tank capacity is that a person requires around 30 litres to 50 litres of hot water per day for various purposes.

Accordingly, for a family with 4 members, around 200 litres of storage tank capacity suffices.

The number of Solar Collector (flat plate or tube type) Calculation

- 10 evacuated tubes generate 100 L hot water a day, therefore, for a family of four, with 200 Liters Per Day requirement = $200 \times 10 / 100 = 220$ evacuated tubes to be installed.
- In general, each person will require between 10 -16 square feet of flat plate collector area. Each square feet of collector area can heat 6-8 litres of water. This is generally considered sufficient for one adult's daily use. Therefore a family of four will need 40-60 square feet of collector plate area which can heat 200-600 litres of water. Standard solar water water heating system in the market are typically available as two standard solar flat plate collectors measuring 32 square feet (4 x 8 ft) each.

Note: It is important to take into account that consumer premises must have an individual water tank with a capacity more than the solar water heater's required capacity. If the consumer has a problem with the water supply, it is better to buy a separate water tank for heating the water with solar.

Difference between Solar Flat Plate Collector and Solar Evacuated Tube Collector

S.No	Evacuated Tube Collector	Flat Plate Collector
1	Quick heat generation	Slow heat generation
2	Collector efficiency at higher temperatures is high	Collector efficiency on higher temperatures is low.
3	Temperature ranges from 60deg. to 120 deg.	Temperature ranges from 60 deg. to 80 deg.
4	Heat loss in the tubes during the daytime is negligible (evacuated tubes)	Heat loss in the collector & tank during the daytime is high due to convection (movement of heat within matter).
5	Lighter and can be easily installed on the roof.	Heavier and takes more space to install. It could be difficult to install it in certain roof spaces.

6	Negligible scaling of tubes that can be cleaned manually (inner tube dia. Is 37mm). Loss of efficiency consequently is minimal	Heavy scaling of the copper/aluminium tubes which cannot be cleaned manually as the bore dia. is 12.50 mm. giving rise to substantial loss inefficiency of the system.
7	The collector glass tube absorbers being cylindrical the incident sun's rays on the tubes is at 90 degrees throughout the day. Hence peak heat absorption always.	The collector fins & tubes being flat the incident sun's rays will be at 90 degrees at noon only for peak absorption.
8	Advanced technology at competitive prices that is System Cost per unit water is low.	Old technology at higher prices
9	Has low maintenance.	Requires high maintenance.

Periodical Maintenance for better output:

- Solar water heaters are very easy to maintain; simple cleaning and visual inspection every 15 days to 1 month is enough to maintain a healthy system.
- Check for leaks in the pipes, tank, panels, and other areas, as leaks are very common in these areas.
- Check for any loose wires or loose wire connections and fix them.
- Maintain a dust-free environment for the panels.
- If you notice a crack in the insulation in the storage tank, make sure it is replaced right away.
- The constant flow of water in the system causes heater corrosion, which leads to solar water heater failure. When the heater is not in use, dry it out to keep it rust-free for a longer period of time. Due to its continuous use, vegetation growth and dust accumulation on the collectors can become a source of concern. As a result, it must be cleaned on a regular basis.
- If you have any plumbing problems, contact your manufacturer or a local service provider as soon as possible.
- In the case of hard water, scale deposits in the collectors will be visible. Acids can be used to dissolve the scale.
- After 2 years, the exposed surfaces should be painted or redone to prevent erosion.

- If any glass is broken within the warranty period, make sure it is replaced by the manufacturer free of cost.

Checklist to install solar water heater:

- Shadow-free space on the roof or open area.
- Suitable roof tilt or requirement of a tilted mounting frame.
- The slope of the thermal collector should be directed towards the south only.
- Calculate required tank capacity as per daily hot water need.

Solar Rooftop System:

The solar rooftop photovoltaic (PV) system consists of solar panels which capture sunlight to transform solar energy into electrical energy. It is the most reliable solution for green power generation nowadays.

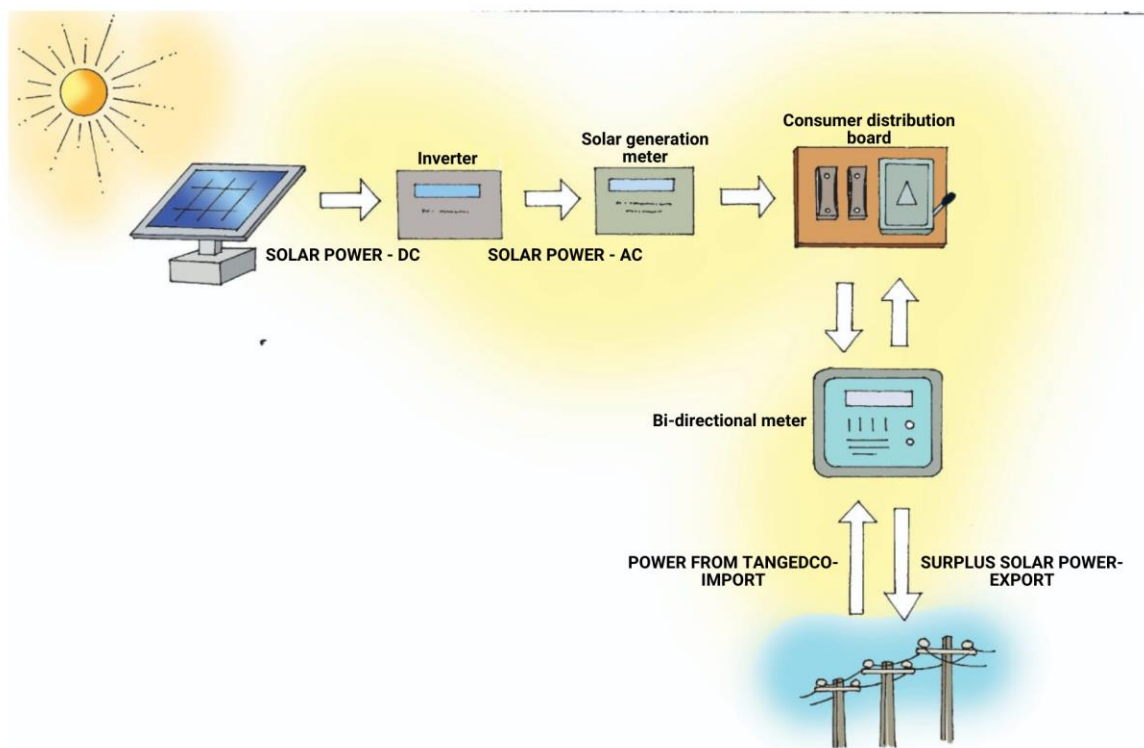


Fig 40: Working of Solar Rooftop Photovoltaic System

Benefits:

- Provides significant savings in electricity bills.
- The initial investment turns out to be high, and is retrievable within 10-12 years, depending on the usage of solar power.

- After recovering, the overall cost of electricity can be free.
- Reduces the carbon footprint of the household.
- Reduces the roof temperature by cutting down direct sunlight on the roof, minimizing the energy consumed by various home appliances.

Components of Solar PV system:

- Solar PV module
- Inverter
- Net meter
- AC breaker panel

Point of Contact:

As per MNRE guidelines, power distribution companies (DISCOMs) functioning in the area for rooftop solar system installation and CFA(Centre Financial Assistance) can be contacted. One can use the DISCOM's portal, if one is available, or go to the DISCOM's local office in the region. (For Tamil Nadu, the DISCOM is TANGEDCO and their website is <https://www.tangedco.gov.in/>)

Procedure for solar power system installation:

Step 1: Inspect the roof conditions. Rooftop panels have a service life of 20-25 years and hence checking the roof conditions becomes a prerequisite. An old or ill-constructed roof hinders the working of the plant to live up to its service life. Spacious and no shade areas of the roof available need to be considered before installation.

Step 2: Setting the tilt angle ie. the angle at which solar panels are fixed in the mounting structure is derived from the latitude of the location. For example, for premises at a latitude of -13.0405° N, the inclination angle for fixing the solar panels in the mounting structure will be 13 degrees. This inclined position also allows for rainwater drainage from solar panels (for an inclination between 15-40 degrees).

Step 3: Weight carrying capacity of the roof to be calculated. Increased weight on the roof due to the system installation can bring huge monetary losses, if the roof is not structurally able to bear this weight. Thus, capacity estimates by professionals are encouraged.

Step 4: Determine the available shade-free area keeping in mind that it is free of hindrances like tall buildings, trees, etc for maximum sunlight to fall on the solar panels. Generally, for 1kW of solar energy to be produced, 12 square meters or 130 square feet of shade-free area is required.

To calculate the required capacity of the solar plant, and annual household energy consumption, one may refer to the physical copies or online account of their annual electricity bill. This total household consumption helps you choose the number of solar panels.

Since a single solar cell (0.5V to 0.6V) doesn't produce enough electricity, a solar panel typically comprises 60 to 72 PV(or photovoltaic) cells depending on whether used for residential or commercial purposes. In case of constrained space, anyone can install a 72 PV cell module. They stand about a foot taller and cost a little less to install in large-scale applications.

Step 5: Weigh the suitability of different solar panels. For instance,

- Monocrystalline (black cells made up of single silicon crystals, expensive and highly efficient between the range of 15-20%) and
- Polycrystalline solar panels (blue cells consisting of multiple silicon crystals, more affordable and less efficient between the range of 13-16%).

A choice can be made considering the consumer's needs and affordability.

Step 6: Check the warranty offered for the panel, inverter, support equipment, and other items before purchasing a solar panel. Solar panels are typically covered by a 20-25 year warranty. Over time the efficiency of solar panels decreases.

Step 7: Finalise the solar installation cost which varies according to the size of the installed capacity. Though the initial investment may appear high, it saves money in the long term by lowering electricity bills and lowering carbon emissions. Setting a budget for the installation before installing a rooftop solar panel helps consumers select the equipment that best suits their requirements and budget. It is best to choose a system that provides value for the money spent.

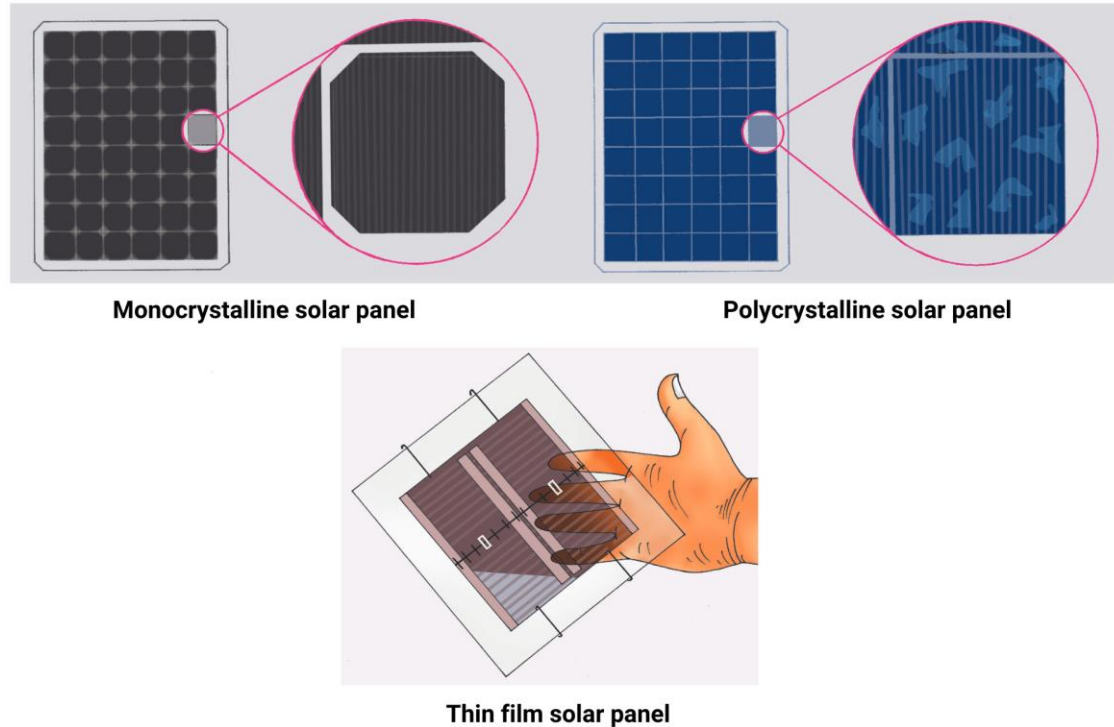


Fig 41: Types of solar panels

Rooftop Solar PV Capacity Calculation:

Rooftop Solar PV system is directly connected to the household meter and can be supplied directly for the use of power.

- **Space required** - 1 kW of solar panel system installation requires around 100 sq. ft. (approximately 10m²) of the shade-free roof area.
- **Orientation** - For individuals in South India, a south-facing roof is excellent considering the slant of the earth's axis and the fact that India is in the northern hemisphere. South-facing rooftops receive the most sunshine.

Maintaining the Solar Rooftop system:

- Regular cleaning of the PV(photovoltaic) modules is required as dust, dirt and rainfall can reduce the energy output. Solar panels must be cleaned properly at least twice in a month.
- The solar panels must be manually checked for dirt, bird droppings, trash, and other detritus. If the system isn't operating, as observed by the online monitoring system, the consumer may clean the panels to troubleshoot.
- Water, soap, and a hose help in cleaning your solar panels. Remember that you shouldn't clean your solar panels with any kind of high-pressure water sprayer.

It's important to take the water's quality into account. Use rainwater as a final rinse if it is available and the water is not hard (mineral-rich) to avoid hard water deposits.

- It is always advisable to keep track of energy bills as higher energy bills can signify lower power generation by the solar panels or an increase in energy consumption from appliances.
- Timely inspection of the functional units of the system to find out any major fall in energy produced to be done.

Checklist for installation of Solar Rooftop system:

- Energy generation assurance of the system
- Warranty and guarantee of the components
- Cross-check the prices for different vendors
- Check whether maintenance services are provided by vendors or not
- Shadow is the second most important parameter for solar radiation collection. Be careful that no shadow penetrates the solar PV module or solar radiation collector plate. That can affect the generation of power or energy.

CAG has published a “ROOFTOP SOLAR INSTALLATION GUIDE FOR TAMIL NADU - A simple practical guide for installing a grid-connected rooftop solar PV system at your premises”. Consumers can refer to this while planning to install a rooftop solar system.

Provisions for installation of solar rooftop system in the future:

Below are certain checkpoints to be aware of, if a consumer plans to install RTS at a later stage:

1. Ensure the availability of safe provision for installing an inverter over the terrace or near the solar panels. This will help to reduce the DC loss from the system. Longer the distance between the solar panels and the inverter, larger the DC loss through the cables.
2. If the premises have more than one floor with a single electrical connection, it is advisable to have individual distribution boxes for each floor, with accessible provision for connecting the AC cables from the inverter to the distribution box.
3. If the premises have more than one floor with multiple electrical connections

but their main distribution boxes are located at the bottom of the floor for ease of assessing the meter readings, then it is advisable to have individual distribution boxes for each floor, with accessible provisions for connecting the AC cables from the inverter to the distribution box.

4. It will be the best option to have a 4 pole MCB for each electrical connection at the terrace or near the solar panels. This will sort out the following issues
 - (i) fixing an inverter for converting DC to AC
 - (ii) connecting AC cables from an inverter to the concerned electrical connections.
 - (iii) the cost of DC Cables is less when compared to AC Cables. However, if the length of the DC Cable is long, it will affect the utilization of power generated from the RTS.

Installing MCBs at the terrace or near the area w.r.t respective connections should be done during building construction as it will be easier then and also pave the way for a convenient RTS installation in the future.

5. The electrical load of a connection should be shared in the premises equally.
6. Ensure the provisions for connecting earthing cables from the solar panels (terrace) to the soil and a water tap at the terrace for cleaning the panels at regular intervals.

Chapter 12

Electric vehicles

Understanding Electric vehicles

The heavy reliance on coal and imported crude oil to meet the rising demands of the population calls for a better alternative that not only reduces international dependence but also proves economical, eco-friendly, and widely accessible.

Electric mobility will help to balance energy demand, storage, and environmental sustainability. Electric vehicles, by relying on a diverse range of primary energy sources for power generation, could help diversify the energy required to move people and goods, greatly improving energy security.

Due to their storage capacity, they may be able to aid in the adoption of clean electricity by allowing for greater use of variable renewable energy in electricity generation. Electric motors in electric vehicles (EVs) are powered by energy stored in batteries. An electric motor replaces the Internal Combustion Engine (ICE) in electric vehicles. Because an EV runs on electricity, it produces no tailpipe emissions (ie., exhaust pipe of a motor vehicle) and does not have components such as a fuel pump, fuel line, or fuel tank.

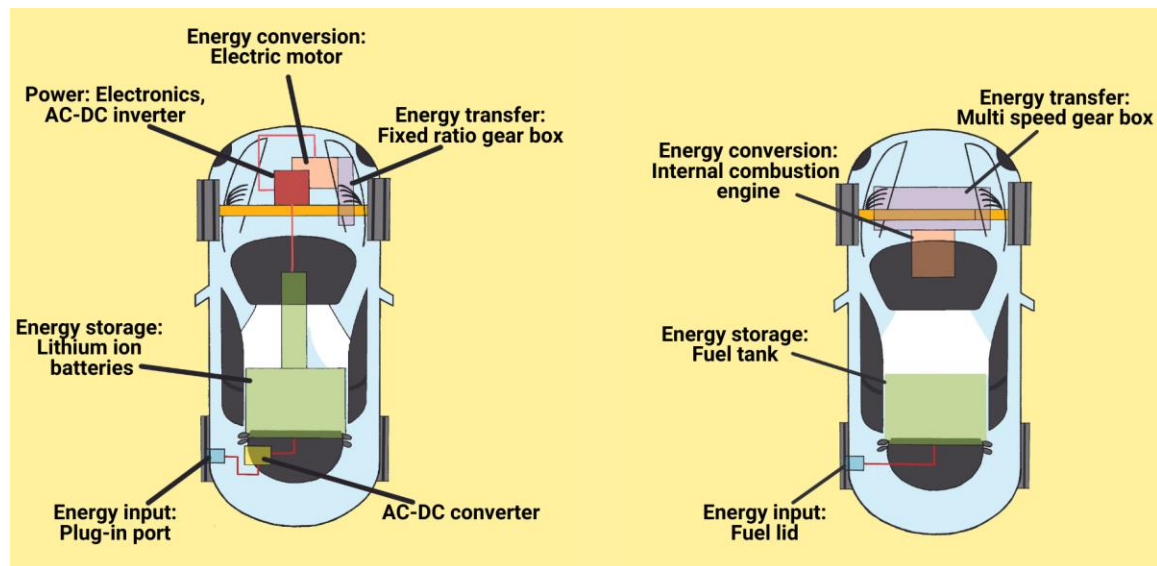


Fig 42: Electric Vehicle vs. Traditional ICE-powered cars | Source: [BEE India](#)

Types of EVs

- In India, EVs are available in four categories, namely pure Battery Electric Vehicles (BEVs), Hybrid Electric Vehicles (HEVs), Plug-in Hybrid Electric Vehicles (PHEVs) and Fuel Cell Electric Vehicles (FCEVs).
 - Battery Electric Vehicles: BEVs also known as All Electric Vehicles (AEVs), have one or more electric motors inside and produce zero road emissions as they don't need any petroleum-based fuels.
 - Hybrid Electric Vehicles: HEVs also known as series or parallel hybrid, combine traditional internal combustion engines with electric propulsion systems. They use regenerative braking to convert energy that would otherwise be wasted during braking, into electricity. A battery is used to store this electricity.
 - Plug-in Hybrid Electric Vehicles: PHEVs also known as series hybrids, have two power systems: an internal combustion engine and a battery. The vehicle's battery can be recharged by connecting it to an external power source. Due to the electric hybrid powertrain, there will be fewer roadside emissions compared to conventional ICE automobiles.
 - Fuel Cell Electric Vehicles: FCEVs also known as Zero-Emission Vehicles, employ 'fuel cell technology' - ie, utilization of chemical energy to generate the electricity required to run the vehicle. They are powered by chemical energy and a battery pack.

Energy Storage Systems in EVs

In EVs, batteries are the most popular type of energy storage technology. Although there are several battery technologies, these are the ones that are most frequently employed: Lithium-ion (Li-ion), lead-acid, and nickel-metal hydride (Ni-MH) batteries.

The parameters related to the battery to be considered before buying an EV are

1. **Capacity and Voltage of the battery:** Battery capacity(or nominal capacity), denoted with the unit kilo-watt hour(kWh), is the maximum amount of current that can be drawn from a fully charged battery to its cut-off voltage, or the battery's lowest possible voltage.

Voltage (given in Volts(V)) is the difference in electrical potential between a battery's anode (the negatively charged end) and cathode (the positively charged end). As a fully charged battery discharges, its voltage gradually decreases. When completely charged, a battery with a nominal voltage of 3.7V might produce 4.3V as an output voltage, and when depleted, it might drop

closer to 3V.

2. **Cost of the battery:** The battery itself is expensive though it is expected to come down owing to increased competition in the future. It is thus advisable to ascertain the maintenance and charging costs before investing in the same.
3. **Battery Lifespan:** Depending on the battery technology, operating temperature, rate of charging, and depth of discharge (related to the battery storing capacity), there is a gradual decline in the original battery capacity, deciding its lifespan. It is advisable to replace the battery if it falls to 80% of its labeled capacity. The number of charges and discharge cycles or the age of the battery in years represents its lifespan.
4. **Performance of the battery:** This is affected by factors such as operating temperatures - low ambient temperature affects a battery's performance, whereas high ambient temperature shortens its lifespan. It also varies depending on the battery type and is between -20 and 65 °C, and specific energy (The unit of measurement for specific energy is Wh/kg, or the amount of stored energy per kilogramme). For a given weight of the storage system, batteries with higher specific energy can store more energy, allowing them to travel farther in kilometers per charge, specific power (representing an electric vehicle's ability to accelerate, for e.g. a battery cannot deliver more than 95 W/kg of battery mass, regardless of run time, if its specific power is 95 W/kg), other factors including battery's chemical composition, the pattern of vehicle use, rate of charging as overcharging is reflected in the battery's performance, safety indicating the chances of it catching fire due to harmful emissions. Therefore, a buyer must make sure the electric car has a reliable battery management system (BMS), which keeps an eye on and regulates variables like the operating temperature, input/output voltage, heat emission, charge and discharge, etc.

Benefits of EVs

- Have fewer mobile components as compared to ICE, thus requiring less maintenance.
- Lower operational as well as fuel costs with higher efficiency, thus more pocket-friendly.
- Availability of government incentives for scrapping ICE vehicles and adopting EVs.
- Income tax deductions to EV owners.
- Reduced import bills due to reduced dependency on imported fuel.

Advantages

- As per the recent government orders, 'No license is needed for EVs.'
- No emissions or smaller carbon footprint unlike ICE vehicles thus help in mitigating air pollution.
- The absence of gears in EVs makes it convenient to drive as compared to ICE vehicles.
- Reduced Noise pollution, thus a calmer driving experience.
- Convenient home charging.
- EVs are vehicles of the future, given the energy crisis and rising fuel demand.

Disadvantages

- The range of electric vehicles, or the distance a vehicle can travel before needing to be recharged, can be an issue. Depending upon the state of charge (amount of available charge), electric vehicles can only run a few kilometres per day.
- Charging station installation could be an additional expense.
- Fewer service facilities compared to ICE vehicles.
- Battery replacement costs for EVs could prove expensive.
- High EV manufacturing costs due to the import of components.
- Lack of abundant charging stations pan India.

Provisions for EV charging

Charging points are the key components for the adoption of EVs. Based on the total parking provisions such as the capacity of parking and type of vehicle, charging infrastructure must be set up in the building premises, for which an additional power and space requirement is essential. EV chargers can be powered from grid power if the connected load is enough or from green energy by installing a solar rooftop at home. It is necessary to ensure a safety factor of 1.25 for the effective functioning of the charging systems.

The electricity connection for an EV charging point or charging facility can be arranged in a variety of ways by an EV owner or CPO i.e. Certified Pre-Owned (with multiple points). Owners of CPOs or EVs should optimize options as per their needs.

The first step in arranging for EV charging electricity is to calculate the required power demand in kilowatts (kW). This is the sum of all the charging points that are part of the planned installation at a given location's rated input requirements. This

would be equivalent to the power required to simultaneously charge the total number of batteries housed in the charging system in the case of a battery charging system. Once the required power demand has been determined, an EV owner or CPO has three options for powering the EV charging infrastructure:

1. Use an existing electricity connection,
2. Get a new electricity connection, or
3. Use a captive renewable energy generation system.

Option 1: Drawing electricity from an existing power connection

Mostly preferred for private charging in a home or office. The following steps must be followed while connecting to an existing power connection.

- Examine the type of connection available at your premise and whether the charging infrastructure's estimated power demand can be met by the available sanctioned load.
- If the existing connection's sanctioned load is insufficient, you must apply to the DISCOM for an increase in the sanctioned load. This may incur additional costs and take some time to be functional.
- If the existing connection type is single-phase LT or three-phase LT, and the increase in sanctioned load exceeds the category's allowed power demand threshold (as defined in the state supply code), you must apply for a three-phase LT or HT connection, respectively. This involves changing the meter, and the applicant will be responsible for certain fees, such as Service Line Cumulation Development (SLD) charges, meter change fees, and so on. The following table lists the type of vehicle and respective charger requirements.

	Power level	Current type	Compatible EV segments
Normal power charging	Less than or equal to 7 kW	AC&DC	<ul style="list-style-type: none"> ● e-2Ws (Electric 2 wheeler), ● e-3Ws (Electric 3 wheeler), ● e-cars, ● other LCVs (up to 1 ton)
High power charging	> 22 kW but less than 50 kW	DC	E-Cars
	> 50 kW but less than 200 kW	DC	

VEHICLE SEGMENTS	Charger Types
E-2W (Electric 2 wheeler)	Single-phase 15A charger
E-Car (Electric Car)	Type-2 AC (70%) and 50 kW DC charger (30%)

For e-2Ws, e-3Ws, and e-cars, standard AC charging is sufficient. Due to the prevalence of LEVs and the use of low-voltage batteries in e-cars, normal power DC charging is unique to India. LEVs and cars with single-phase onboard chargers can use single-phase AC chargers with a maximum power rating of 7kW. For e-cars with larger onboard chargers, three-phase AC chargers with a power rating of up to 22kW are required. The standard electricity distribution network can provide an input power supply for normal power charging.

To take advantage of special EV tariffs, the CPO or EV owner must apply for a separate metered connection (a prepaid connection is also an option) dedicated solely to EV charging, as specified by the SERC in question.

Option 2: Arranging a new electricity connection

CPOs and EV owners can apply for a separate electricity connection for EV

charging in their premises or for standalone charging stations. The procedures for establishing a new electricity connection are similar to those outlined in Option 1.

- If the charging facility is located within your establishment, you may not be able to apply for an exclusive connection if the charging space is not owned by you. However, if there is a formal rent or lease agreement for the space with you and such prepaid connections are permitted by the SERC (State Electricity Regulatory Commission) concerned, you can apply for a separate prepaid EV metered connection for the charging facility up to a certain load.

Option 3: Powering through Captive Renewable Energy Generation

Solar photovoltaic (PV) or solar-wind hybrid systems with stationary energy storage for reliable power supply are typically used to generate captive electricity for EV charging. The available surface area for installing the generation system, as well as site characteristics such as solar insolation and wind profile, are important factors to consider when determining feasibility. A 1 kW solar PV system typically requires about 10 sq m of space to install. To maximize space utilization, the system can be designed as a roof over the charging facility, or it can be mounted on your roof.

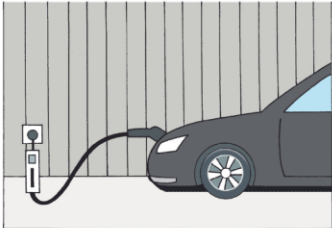
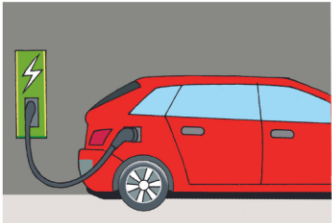
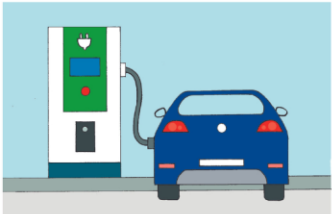
	RANGE (per hour)	APPLICATION
OPTION 1 	2-5 miles	Single family homes, Multi unit residentials.
OPTION 2 	10-30 miles	Single family homes, Multi unit residentials, Workplace, Fleet, Public spaces.
OPTION 3 	150-350+ miles	Multi unit residentials, Fleet, Public spaces.

Fig 43: EV Charging provisions | Source: phoenix.gov

Necessary Safety requirements for EV charging facilities include

- The civil foundation of the EV charger infrastructure must be at least 1 ft above the ground level.
- Protection against overload supply and output supply fittings.
- The enclosure of the charging station shall be made of fire-retardant material.
- The enclosure must have proper ventilation provisions.
- The charging station shall be placed in such a location with no probability of waterlogging.
- The socket outlet of the supply must be at least 800mm above the ground.
- The use of adaptors must be avoided.
- The charging cord length between the charging point and the vehicle must be within 5m.
- A lightning protection system as per IS/IEC 62305 must be provided.
- Fire detection and alarm systems shall be provided as per the IS standards.
- No flammable materials must be kept nearby.
- Earthing must be carried out as per TN system IS 732.
- Periodic maintenance checks must be carried out by an electric inspector every four years.





EV Maintenance Tips

- Regular motor inspection and servicing by an expert in EVs is crucial to maintaining your EV.
- Don't forget to have your brakes serviced. Additionally, avoid driving at excessively high speeds. Driving at an average speed makes the battery last longer and you avoid slamming on the brakes.
- Avoid battery overcharging to lengthen its lifespan. Overcharging may increase pressure inside the battery and cause a thermal runaway. Charging the battery upto 80% is better for the lifetime battery cycle count.
- Avoid using “Quick Charging” stations frequently, Fast charging may generate more heat inside the battery, and excessive heat might reduce the battery's lifespan compared to using a standard charger.
- Make sure to use a certified charger to avoid sparks, short circuits, or damage to the EV.
- Regularly clean the in-home charging points.

Annexure - 1

Load used by home appliances are as follows:

- Types of Lights and their energy consumption

Lumens	Type of bulbs (Power consumed in Watts)			
	Incandescent 	Halogen 	CFL 	LED 
450	40W	29W	11W	9W
800	60W	43W	13W	12W
1100	75W	53W	20W	17W
1600	100W	72W	23W	20W

For TL-D (show high energy efficiency)

Tube Length	Lumens	Power Consumption (in Watt)
60 cm	1200	18W
120 cm	3000	36W
150 cm	5000	58W

- Fan types and their energy consumption

Fan Type	Power Consumed (in watt)
Bladeless Fan	26
Box Fan (10’')	27
Box Fan (20’')	71
Ceiling Fan (36’')	55
Ceiling Fan (48’')	75
Exhaust Fans	35-60
Table/Desk Fans	17-40
Pedestal Fans	30-70
BLDC Fan	30

- For Refrigerators with capacity around 200 litres

Refrigerator-Freezer Type	Power Consumed (in watts)
Single-Door	100
Double-Door	140
Non-Invertor	250

Fridge Capacity	Avg. Wattage of the fridge
100-199	100
200-299	150
300-399	200

400-499	250
500-599	300
600-699	400

- For ACs

Type	1 ton
1 Star AC (mostly non Inverter)	843
2 Star AC (mostly non Inverter)	800
3 Star AC (mix of Inverter and non Inverter)	747
4 Star (mostly Inverter)	645
5 Star (mostly Inverter)	554
Annual Electricity Consumption (Units or kWh for 1600 hrs) based on data from BEE	

- Iron Box : 200W-300W

- For Water Heaters

Water Heater Type	Power Consumed (in watts) (For 15 ltrs of water to be heated)
Instant Water Heater	3000-4000 W
Electric Storage Water Heater	2000 W

- Microwave Oven: 2000W



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