REENERGY FOR INDUSTRIES

CONTENT

FOREWORD

Energy is the driving force of life. Planet Earth is enriched with different energy sources; be it renewable energy sources such as solar, hydro and wind or non-renewable sources such as coal and petroleum. We rely on one or all of them for the purpose of automobiles, electricity, and day-to-day chores. However, the rapidly growing population and rising per capita use of energy result in over exploitation of energy sources and result towards environmental pollution.

Considering the challenges related to energy resources, it is high time to take steps to save energy through education, training and awareness creation. Digital learning is one among the development strategies for energy conservation and resource efficiency, crossing the barriers of state or national borders.

The booklet aims to impart the knowledge of fundamentals of energy, renewable energy, solar energy application, solar application in Industries with some references or examples for the people in management and technical Team of relevant industries.

ABOUT THIS MANUAL

The manual is created as part of the Public Private Partnership project called ENACT funded by DEG and PHOCOS further implemented by ASSIST and Pondicherry University. It introduces the basic concepts of energy, renewable energy, solar energy application and specific solar application in Industries for the Industrial people. As the booklet consists of information about the solar energy, Industrial people are encouraged to use it as a toolkit for industrial activities to match with the working requirement and their interests.

Note to Industrial people: Chapter 1 explained about the introduction about energy, Different forms of energy, Types of energy sources. Chapter 2 elucidated about the types of Renewable Energy. It gives the overall description about the various types of Renewable Energy sources. Chapter 3 provides Solar Energy applications. It deals with the PV and Thermal applications of Solar Energy. Chapter 4 delivers about the Solar Energy applications in industries. It explains in detail about the possible ways to implement the solar energy applications in industries. Chapter 5 illuminate about the example of Solar Energy application implemented in India. Chapter 6 exposed the other applications of Solar Energy. So this chapter shows the various applications of Solar energy which is apart from the normal Solar application. Overall this booklet gives idea about the Energy and Solar Energy applications to the industrial people.

PHOCOS and ASSIST wish you an engaging and informative experience with this manual. The overall design has been chosen carefully to match the needs and preferences of industrial people and to create awareness about sustainable renewable energy and its efficiency.

IMPLEMENTING PARTNERS

DEG a member of the KFW Bankengruppe (KFW banking group), finances investments of private companies in developing and transition countries. As one of Europe's largest development finance institutions, it promotes private business structures to contribute to sustainable economic growth and improved living condition.

Phocos India Solar Pvt. Ltd. (Phocos), a subsidiary of the German Phocos AG in Ulm, World's leading manufacturers of solar-powered charge controllers and components for autonomous power supply.

ASSIST is a non-stock , non-profit international capacity building organization with its headquarters in the phillipines. It aims to achieve and witness meaningful change to and for our planet and the people living on it. Since 2003, ASSIST has implemented over 20 projects funded by multilateral donors such as European union, USAID, UNEP, UNIDO, DEG, GIZ, etc.

Pondicherry University, established under an Act of Parliament in the year 1985, has grown from strength to strength in all possible ways all these years and has become a place on the educational hub of the country. It has all the state-of-the-art facilities in all the Schools and Departments paving the way for the students to have a student-friendly, result-oriented academic environment with green ambience.

CHAPTER 1: INTRODUCTION

ENERGY

Energy is the ability to do work and work is the transfer of energy from one form to another. In practical terms, energy is what we use to manipulate the world around us, whether by exciting our muscles, by using electricity, or by using mechanical devices such as automobiles. Energy comes in different forms - heat (thermal), light (radiant), mechanical, electrical, chemical, and nuclear energy.

VARIOUS FORMS OF ENERGY

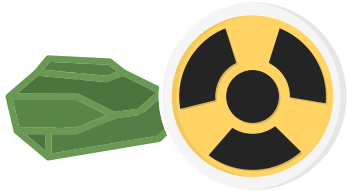
There are two types of energy - stored (potential) energy and working (kinetic) energy. For example, the food we eat contains chemical energy, and our body stores this energy until we release it when we work or play.

POTENTIAL ENERGY

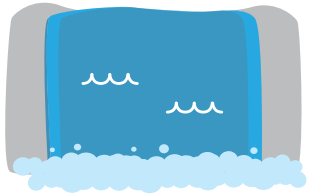
Potential energy is stored energy and the energy of position (gravitational). It exists in various forms.

Chemical energy is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane and coal are examples of stored chemical energy.

Stored mechanical energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.



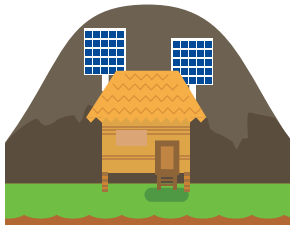
Nuclear energy is the energy stored in the nucleus of an atom— the energy that holds the nucleus together. The nucleus of a uranium atom is an example of nuclear energy.



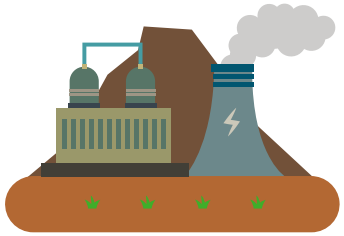
Gravitational energy is the energy of place or position. Water in a reservoir behind a hydropower dam is an example of gravitational energy. When the water is released to spin the turbines, it becomes motion energy.

KINETIC ENERGY

Kinetic energy is energy in motion— the motion of waves, electrons, atoms, molecules and substances. It exist in various forms.

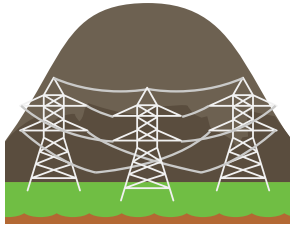


Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Solar energy is an example of radiant energy.



Thermal energy (or heat) is the internal energy in substances- the vibration and movement of atoms and molecules within substances. Geothermal energy is an example of thermal energy.

Motion is the movement of objects or substances from one place to another. Wind and hydropower are examples of motion.



Electrical energy is the movement of electrons. Lightning and electricity are examples of electrical energy.

Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves.

GRADES OF ENERGY

HIGH-GRADE ENERGY

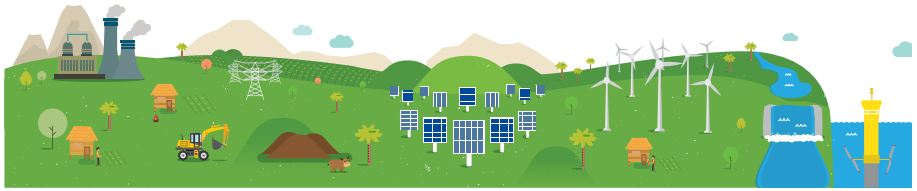
Electrical and chemical energy are high-grade energy, because the energy is concentrated in a small space. Even a small amount of electrical and chemical energy can do a great amount of work. The molecules or particles that store these forms of energy are highly ordered and compact and thus considered as high grade energy. High-grade energy like electricity is better used for high grade applications like melting of metals rather than simply heating of water.

LOW-GRADE ENERGY

Heat is low-grade energy. Heat can still be used to do work (example of a heater boiling water), but it rapidly dissipates. The molecules, in which this kind of energy is stored (air and water molecules), are more randomly distributed than the molecules of carbon in a coal. This disordered state of the molecules and the dissipated energy are classified as low-grade energy.

ENERGY SOURCES

Energy sources can be classified into two types: nonrenewable and renewable. Nonrenewable resources, such as fossil fuels and nuclear material, are removed from the earth and can be depleted. These resources have been the most used type of energy in the modern era. Renewable resources, such as wind, water, solar, and geothermal, come from sources that regenerate as fast as they are consumed and are continuously available. Some, such as biofuel produced from food crops and other plants, are replenished every growing season.



NON RENEWABLE ENERGY SOURCES

Non-renewable energy comes from sources that will run out or will not be replenished in our lifetimes—or even in many, many lifetimes. Most non-renewable energy sources are fossil fuels: coal, petroleum, and natural gas. Carbon is the main element in fossil fuels. All fossil fuels formed in a similar way. Hundreds of millions of years ago, even before the dinosaurs, Earth had a different landscape. It was covered with wide, shallow seas and swampy forests.

However, burning fossil fuels is harmful for the environment. When coal and oil are burned, they release particles that can pollute the air, water, and land. Some of these particles are caught and set aside, but many of them are released into the air.

Coal is a black or brownish rock. We burn coal to create energy. Coal is ranked depending on how much "carbonization" it has gone through. Peat is the lowest rank of coal. It has gone through the least amount of carbonization. Anthracite is the highest rank of coal. Anthracite forms in regions of the world where there have been giant movements of the earth, such as the formation of mountain ranges. We mine coal out of the ground so we can burn it for energy. There are two ways that we can mine coal: underground mining and surface mining.

Coal is a reliable source of energy. We can rely on it day and night, summer and winter, sunshine or rain, to provide fuel and electricity. Using coal is also harmful. Mining is one of the most dangerous jobs in the world. Coal miners are exposed to toxic dust and face the dangers of cave-ins and explosions at work. When coal is burned, it releases many toxic gases and pollutants into the atmosphere. Mining for coal can also cause the ground to cave in and create underground fires that burn for decades at a time.

Petroleum is a liquid fossil fuel. It is also called oil or crude oil. Petroleum is trapped by underground rock formations. In some places, oil bubbles right out of the ground. Remains of animals that got trapped there thousands of years ago are still preserved in the tar. Most of the world's oil is still deep under the ground. We drill through the earth to access the oil. Some deposits are on land, and others are under the ocean floor. Once oil companies begin drilling with a "drill rig," they can extract petroleum 24 hours a day, seven days a week, and 365 days a year. Many successful oil sites produce oil for about 30 years. Sometimes they can produce oil for much longer. Once the oil has been drilled, it must be refined. Oil contains many chemicals besides carbon, and refining the oil takes some of these chemicals out. We use oil for many things. About half of the world's petroleum is converted into gasoline. The rest can be processed and used in liquid products such as nail polish and rubbing alcohol, or solid products such as water pipes, shoes, crayons, roofing, vitamin capsules, and thousands of other items.

There are advantages to drilling for oil. It is relatively inexpensive to extract. It is also a reliable and dependable source of energy and money for the local community. Oil provides us with thousands of conveniences. In the form of gasoline, it is a portable source of energy that gives us the power to drive places. Petroleum is also an ingredient in many items that we depend on.

However, burning gasoline is harmful to the environment. It releases hazardous gases and fumes into the air that we breathe. There is also the possibility of an oil spill. If there is a problem with the drilling machinery, the oil can explode out of the well and spill into the ocean or surrounding land. Oil spills are environmental disasters, especially offshore spills. Oil floats on water, so it can look like food to fish and ruin birds' feathers.

CHAPTER 2: TYPES OF RENEWABLE ENERGY

RENEWABLE ENERGY

Renewable energy sources also called non-conventional energy, are sources that are continuously replenished by natural processes. For example, solar energy, wind energy, bio-energy, bio-fuels grown sustain ably), hydropower etc., are some of the examples of renewable energy sources.

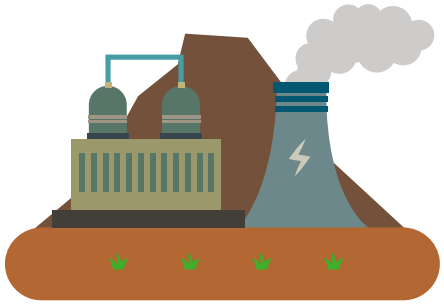
A renewable energy system converts the energy found in sunlight, wind, falling-water, sea waves, geothermal heat, or biomass into a form, we can use such as heat or electricity. Most of the renewable energy comes either directly or indirectly from sun and wind and can never be exhausted, and therefore they are called renewable.

However, most of the world's energy sources are derived from conventional sources-fossil fuels such as coal, oil, and natural gases. These fuels are often termed non-renewable energy sources. Although, the available quantity of these fuels are extremely large, they are nevertheless finite and so will in principle 'run out' at some time in the future . Renewable energy sources are essentially flows of energy, whereas the fossil and nuclear fuels are, in essence, stocks of energy.

VARIOUS FORMS OF RENEWABLE ENERGY

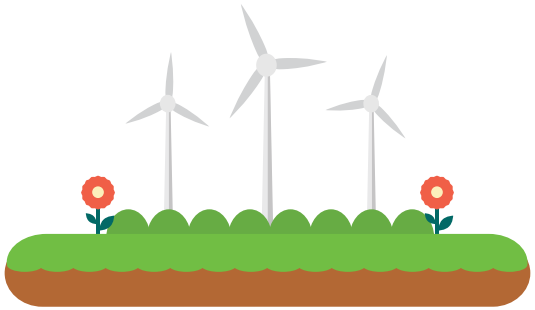
Solar energy is the most readily available and free source of energy since prehistoric times. It is estimated that solar energy equivalent to over 15,000 times the world's annual commercial energy consumption reaches the earth every year. India receives solar energy in the region of 5 to 7 kWh/m2 for 300 to 330 days in a year. This energy is sufficient to set up 20 MW solar power plant per square kilometre land area.

Solar energy can be utilised through two different routes, as solar thermal route and solar electric (solar photovoltaic) routes. Solar thermal route uses the sun's heat to produce hot water or air, cook food, drying materials etc. Solar photovoltaic uses sun's heat to produce electricity for lighting home and building, running motors, pumps, electric appliances, and lighting.



Geothermal energy is the heat from the Earth. It's clean and sustainable. Resources of geothermal energy range from the shallow ground to hot water and hot rock found a few miles beneath the Earth's surface, and down even deeper to the extremely high temperatures of molten rock called magma. Almost everywhere, the shallow ground or upper 10 feet of the Earth's surface maintains a nearly constant temperature between 50° and 60°F (10° and 16°C).

Geothermal heat pumps can tap into this resource to heat and cool buildings. A geothermal heat pump system consists of a heat pump, an air delivery system (ductwork), and a heat exchanger-a system of pipes buried in the shallow ground near the building. In the winter, the heat pump removes heat from the heat exchanger and pumps it into the indoor air delivery system. In the summer, the process is reversed, and the heat pump moves heat from the indoor air into the heat exchanger. The heat removed from the indoor air during the summer can also be used to provide a free source of hot water.

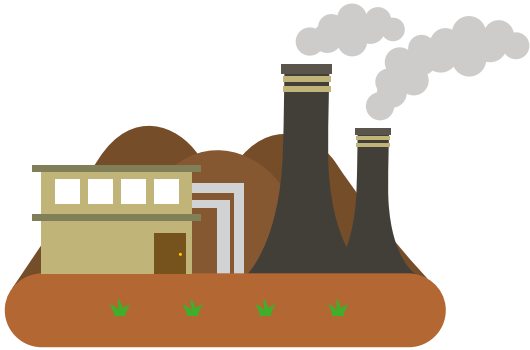


Wind energy is basically harnessing of wind power to produce electricity. The kinetic energy of the wind is converted to electrical energy. When solar radiation enters the earth's atmosphere, different regions of the atmosphere are heated to different degrees because of earth curvature. This heating is higher at the equator and lowest at the poles. Since air tends to flow from warmer to cooler regions, this causes what we call winds, and it is these airflows that are harnessed in windmills and wind turbines to produce power.

Wind power is not a new development as this power, in the form of traditional windmills -for grinding corn, pumping water, sailing ships - have been used for centuries. Now wind power is harnessed to generate electricity in a larger scale with better technology. The wind speed is the most important factor influencing the amount of energy a wind turbine can produce. Increasing wind velocity increases the amount of air passing the rotor, which increases the output of the wind system.

The basic wind energy conversion device is the wind turbine. Although various designs and configurations exist, these turbines are generally grouped into two types. First one Vertical-axis wind turbines, in which the axis of rotation is vertical with respect to the ground (and roughly perpendicular to the wind stream), second one is Horizontal-axis turbines, in which the axis of rotation is horizontal with respect to the ground (and roughly parallel to the wind stream.)

The subsystems include a blade or rotor, which converts the energy in the wind to rotational shaft energy, a drive train, usually including a gearbox and a generator, a tower that supports the rotor and drive train, and other equipment, including controls, electrical cables, ground support equipment, and interconnection equipment.



Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the wood industry, agricultural crops, raw material from the forest, household wastes etc. Biomass does not add carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as a fuel.

Its advantage is that it can be used to generate electricity with the same equipment that is now being used for burning fossil fuels. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas. Bio-energy, in the form of biogas, which is derived from biomass, is expected to become one of the key energy resources for global sustainable development.

Biogas Plants

Biogas is a clean and efficient fuel, generated from cow-dung, human waste or any kind of biological materials derived through anaerobic fermentation process. The biogas consists of 60% methane with rest mainly carbon-di-oxide. Biogas is a safe fuel for cooking and lighting. By product is usable as high-grade manure.

Bio fuels

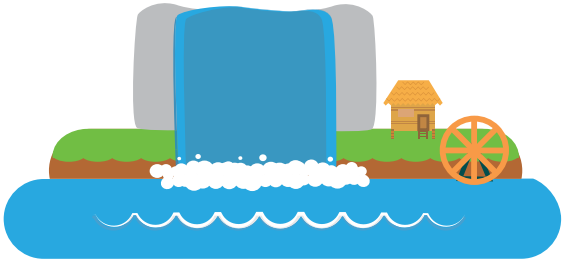
Unlike other renewable energy sources, biomass can be converted directly into liquid fuels biofuels for our transportation needs (cars, trucks, buses, airplanes, and trains). The two most common types of biofuels are ethanol and biodiesel. Biodiesel, produced by plants such as rapeseed (canola), sunflowers and soybeans, can be extracted and refined into fuel, which can be burned in diesel engines and buses. Biodiesel can also made by combining alcohol with vegetable oil, or recycled cooking greases. It can be used as an additive to reduce vehicle emissions (typically 20%) or in its pure form as a renewable alternative fuel for diesel engines.

Biomass Briquetting

The process of densifying loose agro-waste into a solidified biomass of high density, which can be conveniently used as a fuel, is called Biomass Briquetting. Briquette is also termed as “Bio-coal”. It is pollution free and ecofriendly. Some of the agricultural and forestry residues can be briquetted after suitable pre-treatment. Some of advantages of biomass briquetting are high calorific value with low ash content, absence of polluting gases like sulphur, phosphorus fumes and fly ash- which eliminate the need for pollution control equipment, complete combustion, ease of handling, transportation & storage because of uniform size and convenient lengths.

Biomass Cogeneration

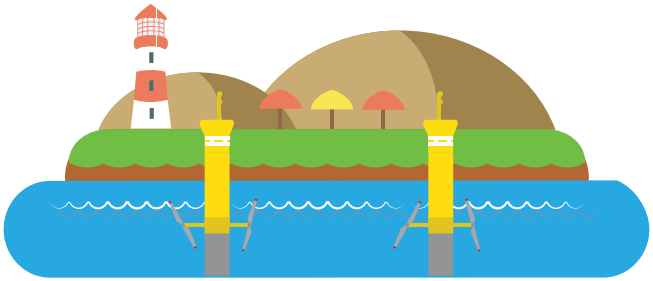
Cogeneration improves viability and profitability of sugar industries. Indian sugar mills are rapidly turning to bagasse, the leftover of cane after it is crushed and its juice extracted, to generate electricity. This is mainly being done to clean up the environment, cut down power costs and earn additional revenue. According to current estimates, about 3500 MW of power can be generated from bagasse in the existing 430 sugar mills in the country. Around 270 MW of power has already been commissioned and more is under construction.



Hydro energy is the potential energy of falling water, captured and converted to mechanical energy by waterwheels, powered the start of the industrial revolution. Wherever sufficient head, or change in elevation, could be found, rivers and streams were dammed and mills were built. Water under pressure flows through a turbine causing it to spin. The Turbine is connected to a generator, which produces electricity.

In India the potential of small hydro power is estimated about 10,000 MW. A total of 183.45 MW small Hydro project have been installed in India by the end of March 1999. Small Hydro Power projects of 3 MW capacity have been also installed individually and 148 MW project is under construction.

Small Hydro Power is a reliable, mature and proven technology. It is non-polluting, and does not involve setting up of large dams or problems of deforestation, submergence and rehabilitation. India has an estimated potential of 10,000 MW.



Tidal Energy

Tidal electricity generation involves the construction of a barrage across an estuary to block the incoming and outgoing tide. The head of water is then used to drive turbines to generate electricity from the elevated water in the basin as in hydroelectric dams. Barrages can be designed to generate electricity on the ebb side, or flood side, or both. Tidal range may vary over a wide range (4.5-12.4 m) from site to site. A tidal range of at least 7 m is required for economical operation and for sufficient head of water for the turbines.

Ocean Energy

Oceans cover more than 70% of Earth's surface, making them the world's largest solar collectors. Ocean energy draws on the energy of ocean waves, tides, or on the thermal energy (heat) stored in the ocean. The sun warms the surface water a lot more than the deep ocean water, and this temperature difference stores thermal energy. The ocean contains two types of energy: thermal energy from the sun's heat, and mechanical energy from the tides and waves.

Ocean thermal energy is used for many applications, including electricity generation. There are three types of electricity conversion systems: **closed-cycle, open cycle, and hybrid**.

Closed cycle systems use the ocean's warm surface water to vaporize a working fluid, which has a low boiling point, such as ammonia. The vapour expands and turns a turbine. The turbine then activates a generator to produce electricity.

Open-cycle systems actually boil the seawater by operating at low pressures. This produces steam that passes through a turbine / generator. The hybrid systems combine both closed-cycle and open-cycle systems.

Ocean mechanical energy is quite different from ocean thermal energy. Even though the sun affects all ocean activity, tides are driven primarily by the gravitational pull of the moon, and waves are driven primarily by the winds. A barrage (dam) is typically used to convert tidal energy into electricity by forcing the water through turbines, activating a generator.

CHAPTER 3: SOLAR ENERGY APPLICATION PHOTOVOLTAIC AND THERMAL

SOLAR ENERGY APPLICATIONS

- Solar Photo Voltaic Applications
- Solar Thermal Applications

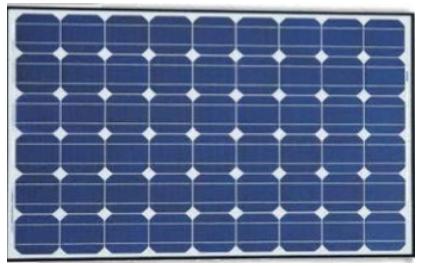
SOLAR PHOTO VOLTAIC APPLICATIONS

The direct conversion of solar energy into electrical energy by means of the photovoltaic effect, that is the conversion of light (or other electromagnetic radiation) into electricity. Energy conversion devices sunlight to electricity by the use of the photovoltaic effect are called solar cells. Photovoltaic cells are made of a semiconductor electricity. PV cells are most varieties, crystalline and thin-film type.

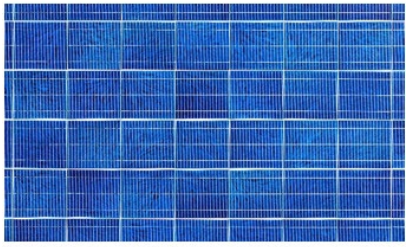
When a photon is absorbed by a semiconducting material, it increases the energy of a valence band electron, thrusting it into the conduction band. This occurs when the energy of incident photons is higher than the bandgap energy. The conducting band electron then produces a current that moves through the semiconducting material.

PV cells can be arranged in a series configuration to form a module, and modules can then be connected in parallel-series configurations to form arrays. When connecting cells or modules in series, they must have the same current rating to produce an additive voltage output, and similarly, modules must have the same voltage rating when connected in parallel to produce larger currents.

PHOTOVOLTAIC PANEL TYPES:

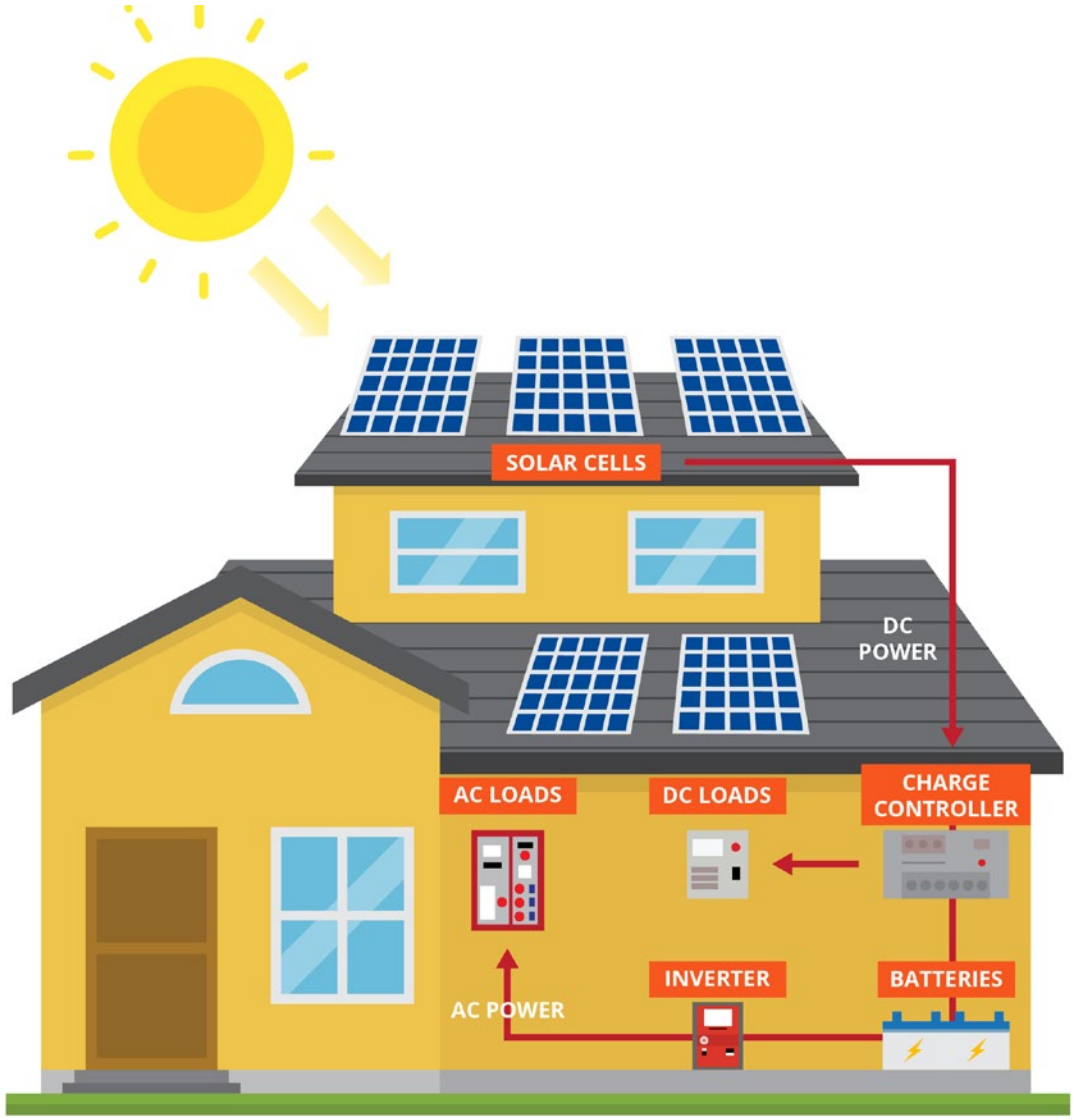


Mono Crystalline Photovoltaic Panel



Poly Crystalline Photovoltaic Panel

Thin Film Photovoltaic Panel



The diagram shows the working principles of Solar PV system. The Solar PV panels are connected With Charge Controller.

The charge Controller main function is to fully charge a battery without permitting overcharge or reverse current flow (generally during night). Then the charge Controller is connected with Batteries.

A battery is a device that converts the chemical energy contained in its active materials directly into electrical energy by means of an electrochemical oxidation reduction (redox) reaction.

In the case of the rechargeable system, the battery is recharged by a reversal of the process. This type of reaction involves the transfer of electrons from one material to another through an electric circuit.

The Battery is connected with DC loads. If we want to Connect Ac Loads then the battery is connected with Inverter. The Inverter is an electronic device or circuitry that changes direct current (DC) to alternating current (AC).

The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. Next the inverter is connected with AC Loads.

SOLAR THERMAL APPLICATIONS

Solar thermal energy is an energy derived from sun and being used for thermal oriented applications inclusive of water heating and Electricity production. The light energy obtained from the sun is converted into the required form of thermal energy by virtue of solar thermal energy equipment/appliances. Solar water heater, solar cooker, solar still and solar drier are the few examples of solar thermal applications. Power plants are operated with solar thermal techniques.

SOLAR WATER HEATER

A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water. The solar energy incident on the absorber panel coated with selected coating transfers the heat to the riser pipes underneath the absorber panel. The water passing through the risers get heated up and are delivered the storage tank. There-circulation of the same water through absorber panel in the collector raises the temperature to 80° C (Maximum) in a good sunny day. The total system with solar collector, storage tank and pipelines is called solar hot water system. The SHW systems are economical, pollution free and easy for operation in warm countries like ours. Based on the collector system, solar water heaters can be of two types.

Flat Plate Collectors (FPC) based Solar Water Heaters, The solar radiation is absorbed by Flat Plate Collectors which consist of an insulated outer metallic box covered on the top with glass sheet. Inside there are blackened metallic absorber (selectively coated) sheets with built in channels or riser tubes to carry water. The absorber absorbs the solar radiation and transfers the heat to the flowing water.

Evacuated Tube Collectors (ETC) is made of double layer borosilicate glass tubes evacuated for providing insulation. The outer wall of the inner tube is coated with selective absorbing material. This helps absorption of solar radiation and transfers the heat to the water which flows through the inner tube. Solar water heating is now a mature technology. Wide spread utilization of solar water heaters can reduce a significant portion of the conventional energy being used for heating water in homes, factories and other commercial and institutional establishments.

SOLAR COOKER

Solar cooker is a device that cooks food using only solar radiation and can save the conventional fuels to a significant amount. It is the simplest, safest, most convenient way to cook food without consuming fuels or heating up the kitchen. Solar energy is abundantly available worldwide and it is possible to cook noon meal for 4 to 5 people in a normal box type solar cooker on clear sunny days. Concentrating solar cookers can cook food for large number of people.

Box Type Solar Cooker

It essentially consists of a black painted metallic trapezoidal tray (Cooking tray) and is usually covered with a double glass window. It is kept in a metal or fiber-glass outer casing and the space between the cooking tray and outer casing is filled with the insulation like glass wool. The incoming solar radiation falls onto the double glass lid and passes through it to strike the blackened cooking pots and the cooking tray. The glass covers, while transmitting radiation of short wavelength which form major part of solar spectrum, is almost opaque to low temperature radiation emitted within the box. Thus, the temperature of the box rises until a balance is reached between the heat received through glazing and heat lost by exposed surface. The cooking tray is insulated on the sides and bottom. The heat is absorbed by the blackened surface and gets transferred to the food inside the pots to facilitate cooking.

Concentrating Type Solar Cooker

Concentrating type solar cookers primarily consist of a reflector to focus the incident solar radiation on the cooking pot, a support with turning mechanism to keep the reflector facing the sun, and a cooking pot. The size (and hence cost) of the reflector is determined by the heating capacity desired. The approach used for concentrating solar radiation on the cooking pot(s) either makes use of plane mirrors arranged in a specific manner or metallic reflectors.

SOLAR STILL

Solar distillation is a process where solar energy is used to produce fresh water from saline or brackish water for drinking, domestic and other purposes. Solar distillation appears as one of the mass production of fresh water from high saline water like seawater. High energy cost of the evaporation process contributes most of the running expenditure in various distillation methods. The advantage of solar energy based small desalination plant is the requirement of small quantities of energy which is mostly collected from the sun. Its principle of operation is the greenhouse effect; the radiation from the sun evaporates water inside a closed glass covered chamber at a temperature higher than the ambient. The cool transparent leaning surface made of glass or plastic. The droplets slide down along the leaning surface and are collected through special channels located under the leaning surface.

SOLAR DRIER

It is one of the most important means for the preservation of many kinds of agricultural products. Open sun drying, where the product is exposed directly to the sun allowing the solar radiation to be absorbed by the material, is one of the oldest techniques employed in agriculture. The solar drier is a structure made for drying the agro products effectively by utilizing the Green House effects. Since the rural or remote areas of India are not connected to the national electric grid and remote areas of India facing energy crisis, the use of solar technology has often been suggested for the dried fruit industry both to reduce energy costs They give faster drying rates by heating the air to 10-30°C above ambient, which causes the air to move faster through the drier, reduces its humidity and deters insects. Solar driers also protect foods form dust, insects, birds and animals.

CHAPTER 4: SOLAR APPLICATION IN INDUSTRIES

Commercial applications mostly use conventional heating systems based on electricity/coal/furnace oil/wood. Due to constant increase in cost of electricity and conventional fuels, solar water heater can be best solution for hot water requirement of industries as payback time would be average 1.5 years. If high temperature water in needed in industrial application, solar water heater can be used to heat water at preheating stage. For example, once water is heated by solar water heater up to 40 to 70 Deg. C depending on atmospheric conditions, then electric/coal/furnace oil/gas can be used to provide boosting to increase temperature of hot water and hence Industry can save heavily as solar water heater takes temperature of hot water to a preheating stage.

Hotels: Bathing, kitchen, washing, laundry applications

Dairies: Ghee (clarified butter) production, cleaning and sterilizing, pasteurization

Textiles: Processing, bleaching, boiling, printing, dyeing, curing, ageing and finishing applications

Edible Oil and Refining: Boiler feed applications

Breweries: Bottle washing, wort preparation, boiler feed applications

Distilleries: Bottle washing, boiler feed applications

Bulk Drugs Manufacturing Units: Fermentation of mixes, boiler feed applications

Electroplating / Galvanizing Units: Heating of plating baths, cleaning, degreasing applications

Paint Shops: cleaning, degreasing applications

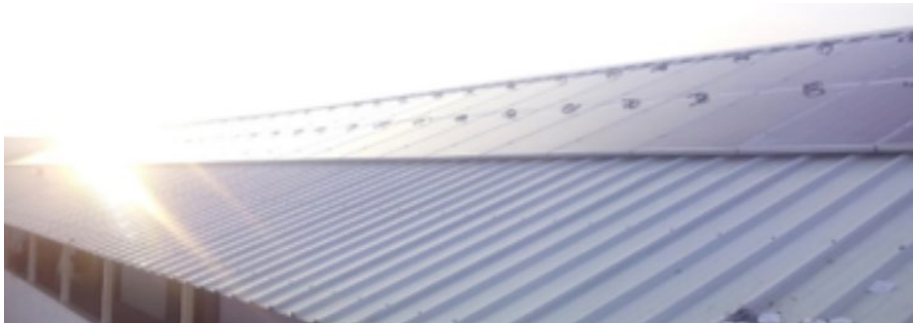
Pulp and Paper Industries: Boiler feed applications, soaking of pulp

Soft Drink Bottling Plants: cleaning of bottles & vessels, boiler feed application

EXAMPLES OF SOLAR INSTALLATION - PHOCOS INDIA SOLAR PVT LTD

EXAMPLE 1

Jain Engineering College was established in 1984 was involved in imparting professional education and skills training to make the students competent in their chosen field of engineering. This college has installed 25kW on-grid system with hundred number of 250 Watts for the usage of college electronic appliances like light, fan, projector, lab facilities, motor, air conditioner.



IMAGES DURING AND AFTER INSTALLATION

EXAMPLE 2

Adyar Ananda Bhavan Sweets and Snacks popularly known as A2B, pioneer in food industry and having over 95 branches across India, who commit quality and high degree of professionalism in manufacturing sweets, savouries and snacks. Phocos India has installed solar refrigeration systems with 200Watts solar panels in order to store perishable food products at 5 different locations of A2B.

EXAMPLE 3

HUL – Puducherry is involved in manufacturing affordable & luxurious soaps, shampoos and everyday household products. They produce more than 400 brands in personal care and hygiene sector for the well-being of the people. Phocos was associated with this factory in installing twelve number of 250 watt panels to produce 3kW energy for their complete lighting system in their factory premises.

EXAMPLE 4

The Pondicherry Cooperative Milk Producers' Union is the first cooperative society registered in the year 1955 in the Union Territory of Puducherry as Pondicherry Cooperative Milk Supply society which has capacity to handle 50,000 litres per day. The Pondicherry Cooperative Milk Producers' Union is selling their different varieties of milk and milk products in the Puducherry market under the brand name "Ponlait". Phocos was associated with Phocos to install solar systems at two of their outlets. One with 1kW off-grid to operate all the lighting system using AC LED tube lights. Another outlets has also 1 kW off grid to operate the solar.

EXAMPLE 5

Leo Fastners Pondicherry are the leading Suppliers and manufacturers of 10 nut formers, 1 nut part former, nut size from m3 ~ 16, 5.5 hex to 27 hex. Phocos was associated with them in installing 20kW solar grid tied power systems through eighty number of 250Watts for their entire factory to operate light, fan, projector, lab facilities, motor, air conditioners.

EXAMPLE 6

A Hotel at Pondicherry has installed twenty number of 250Watts solar panels to produce 5kW energy both on-grid and off-grid model in order to use appliances like lighting loads, five freezers, heavy duty grinders and mixers, motors and air conditioners.

EXAMPLE 7

Kodaikanal, is a tourism spot commonly known as ‘Princess of hills’ located in the Palani hills of Tamilnadu. MVM cottage located in this region approached Phocos to install 3kW off grid system to match their energy requirements for operating the entire lighting loads. After this process, the cottage management realized the effectiveness of solar energy and observed the reduction of electricity consumption hence planned to extend the solar appliances through installing solar water heaters.

SOLAR INCUBATING SYSTEM

A company called ‘Life way solar’ innovated a solar incubator with 12 v/40 watt solar panels, and a battery of capacity 100 amp hours with Phocos manufactured product called Charge controller of 20 amps in Kerela. This innovation was a great successful and could be utilized to hatch 40 eggs at a time with this solar capacitated incubator which was on a high deman in the region among the poultry farmers. Another advantage of this innovation is that, the capacity could be increased up to 400 eggs by increasing the number of panel and battery capacities.

CHAPTER 5: SOLAR POWER MODELS IN INDIA

MAHARASTRA'S PILGRIMAGE PROVES SOLAR EFFICIENCY

Shirdi is another famous pilgrimage centre located in Maharashtra distributes prasadhams made up of solar energy. This solar generated energy could serve 20000 devotees per day. At the roof top of the kitchen complex, 73 parabolic antennas are mounted to utilize the Sun's rays for efficiency. The system was installed in the year 2009 and one among the world's largest solar steam system. Because the production of prasadams with these efficient technologies saves Rs 10500per day towards LPG.

The total cost for setting up the system is Rs133 lakhs, in which Rs58.40 lakhs was provided by the ministry as a subsidy. Initially the temple had only 40 dish antennas which were inadequate to meet the increasing number of devotees.

The Shirdi solar cooking system was designed in a way that it could manage even without electricity to run the feeder water pump for circulating water in the system. The antennas concentrate solar rays to generate steam with temperature between 550 to 600 degrees Celsius. The dishes rotate along with the direction of the Sun in order to harness the maximum heat with the automatic tracking system. But the

antennas should be turned manually in line with the position of the sun every morning and then the automatic tracking takes care of rotation. Additionally to increase the efficiency of the system during non-sunshine hours, the complete system is linked with the boilers but could manage only for few hours. The total system utilize sun light to produce 3500kg of steam daily. Considering the cost effectiveness, the annual savings translates about 100,000 kg of LPG which equals to Rs 20 lakhs.

TIRUPATHI, A PIONEER OF SOLAR COOKING IN INDIA

Tirumala Tirupathi Devasthanam(TTD) located in Andhra Pradesh in one of the very famous pilgrimage centre in India. People from all over the world and country, visit the temple throughout the year. Hence the temple authorities are in need to provide food to its devotees at a larger scale, which resulted in shortage of fuel and electricity.

They successfully faced this issue by tapping the solar resource, which is available plentiful in our country. They set up a huge solar cooking system with the automatic tracking concentrators which enabled the TTD to serve 15000 devotees per day. This system converts the water into high pressure steam and the steam is further used for cooking. Additionally this steam is connected to a diesel boiler to ensure the systems usability and reliability despite different climatic conditions.

The system was launched in the year 2002 and it can save around 1,18,000 litres of diesel and the total estimated profit was 17 lakhs per year. Whereas the total cost of Rs1.1 crores was shared equally by the Ministry of Renewable Energy Sources and TTD trust. This solar empowered technology will be very useful for large scale cooking especially rice. This system reduces carbon dioxide emission by 1.2 tonnes per day.

Besides the savings TTD trust now sells the emission reduction credits to a Swiss company who takes care of the energy and ecology in addition of giving revenue.

THE COCHIN INTERNATIONAL AIRPORT TO OPERATE COMPLETELY ON SOLAR POWER

The Cochin International Airport on Tuesday became the first in the world to operate completely on solar power. Kerala Chief Minister Oommen Chandy inaugurated the 12 MWp solar power plant, comprising 46,150 solar panels laid across 45 acres near the cargo complex. With this, the airport will have 50000 to 60000 units of electricity per day to be consumed for all its operational functions, which technically makes the airport 'absolutely power neutral,' Cochin International Airport Limited (CIAL) said in a release, adding, it is the first airport in the world to operate completely on solar power.

CIAL had ventured into the Solar PV sector during March 2013, by installing a 100 kWp solar PV Plant on the roof top of the Arrival Terminal Block. This was a trendsetter in the field of grid-connected solar PV in Kerala. The plant was installed by the Kolkata-based Vikram Solar Pvt. Ltd. A total of 400 polycrystalline modules of 250Wp with five numbers of 20kW capacity 'Refu-sol make string inverters' were used in this plant. It is a grid connected system without any battery storage. After the successful commissioning of this plant, CIAL installed a 1 MWp solar PV power plant partly on the roof top and partly on the ground in the Aircraft Maintenance Hangar facility within the airport premises.

This plant was installed by Emvee Photovoltaic Power Pvt. Ltd. 4000 monocrystalline modules of 250Wp with 33 numbers of 30kW capacity Delta make string inverters were used in this plant, which is the first

Megawatt scale installation of solar PV system in Kerala, the release said. Both these plants are equipped with a SCADA system, through which remote monitoring is carried out. After commissioning, these plants have so far saved more than 550MT of CO2 emission contributing to the efforts of CIAL towards minimising environmental degradation, CIAL said.

ROOF TOP SOLAR SYSTEM THAT CAN REPLACE 20 TO 25 TONNES OF LPG ANNUALLY

Harita Seating Systems Ltd is a leading manufacturer of automotive seating systems in India. They are part of $7 billion TVS group. With Design, Comfort, Safety and Innovation as its core elements, Harita Seating Systems has emerged as a trendsetter in the field of automotive seating in India. They have facilities of Seat frame manufacturing, powder coating, upholstery cut and sew, and seat assembly. The company used liquefied petroleum gas (LPG) for their heating requirements in their pre-treatment processes as described in the table below. Harita´s processes require the tank / bath to be maintained at a particular process temperature. Harita explored the use of solar energy due to the rising cost of LPG and emphasizing long term environmental concerns.

The Solar thermal energy from rooftop evacuated tube collectors is transported through pumps and piping and delivered to the process through a dedicated heat exchanger in each bath using a closed loop circulation system. The imported double glass vacuum tube based collectors are mounted on unused south-facing factory roofs. Aspiration Energy has done incremental innovation to the glass tubes and the placement of collectors, ensuring achievement of 1200 C at the roof, so the required temperature is rendered in the tanks.

This system has the potential to replace 20 to 25 tonnes of LPG per year. The resultant savings is much more than the monthly rental paid by Harita to their financing institution, from whom they have leased the solar system. After the repayment period of five years, Harita will benefit from the solar thermal energy delivered by the system, free of cost (except negligible costs in cleaning and maintenance) for the remaining asset life of 10-15 years.

Reference: www.aspirationenergy.com

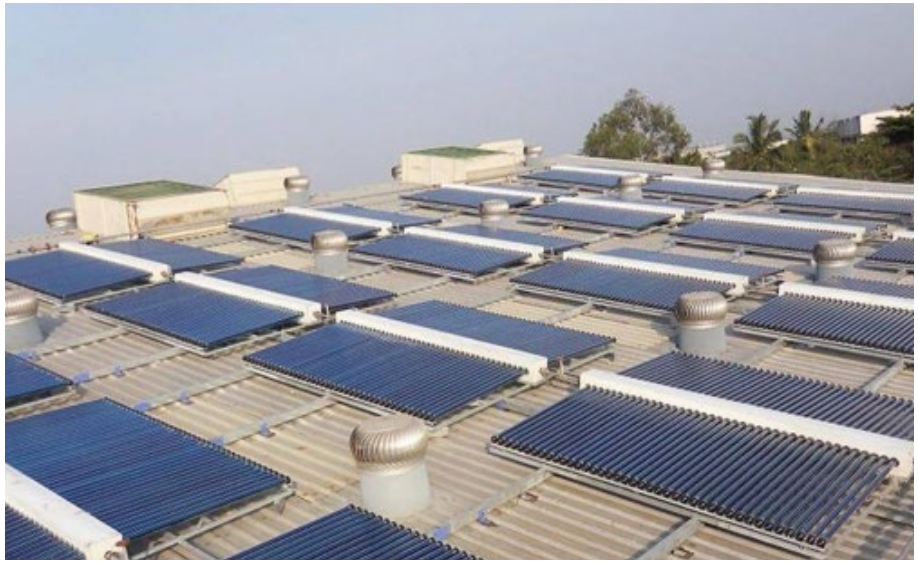
210 kW CAPACITY OF SOLAR THERMAL SYSTEM FOR A STEERING SYSTEM MANUFACTURER

Sona Koyo Steering Systems Limited (SKSSL) the flagship company of The Sona Group, is currently the largest manufacturer of steering systems for the passenger car and utility vehicle market in India. Their customers include major vehicle manufactures in India such as Maruti Suzuki, Toyota, Hyundai, Tata Motors, Mahindra & Mahindra, General Motors and Mahindra-Renault.

As part of their production process, steering components undergo a hot water wash at 60ºC to remove dust & rust followed by hot caustic solution wash at 75ºC to remove oil and finally hot phosphating at 70ºC. In their Chennai manufacturing plant, they used Diesel based pressurized hot water (100 to 110ºC) heater for heating the process tanks to the required temperature. In order to maintain the tanks at those temperature ranges, Sona Koyo was consuming 120 L of Diesel per day. Solar Energy was evaluated to replace this fuel load.

An online Roof top Solar Thermal System of 210 KW capacity, giving heat transfer fluid circulative system at 120ºC for their components wash & coat application. This system in integration with their existing hot water heater provides a very reliable heat source at much reduced fuel consumption.

The system is designed with butterfly-shaped Evacuated Glass Tube Collectors (ETC). Each ETC module is rated at 6 KW thermal capacity



with 13 sq. m aperture area. Heat Transfer Fluid flows through the glass tubes and the solution is heated up by the sun's rays. The process tanks are heated up through indirect heating. The heat exchanger is of Plate Type, in one side the hot heat transfer fluid will pass through and the other side the circulating water for cleaning the components is passed.

Reference: www.aspirationenergy.com

OTHER MODEL APPLICATIONS ON SOLAR

SOLAR CAR

SOLAR TRICYCLE

SOLAR PHONE CHARGER

SOLAR LANTERN

SOLAR AUTO

SOLAR STREET LAMP

SOLAR FLIGHT