भारतीय ज्ञान परंपरा

संस्कृति, दर्शन, शैक्षिक विचारधाराएँ और नवाचार

सम्पादक :
डॉ. दिनेश चन्द्र शर्मा

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Ph.D., D.Lit. (Sub.)

निदेशक, कॉम्पिटिशन प्लस ग्रुप ऑफ इन्स्टीट्यूशन,

अजमेर

छवि पब्लिकेशन्स

अजमेर-305001

प्रकाशक :
छवि पब्लिकेशन्स
अजमेर-305001
मो. 9660111549

संस्करण :
प्रथम 2022-2023

ISBN : 978 - 81 - 89435 - 64 - 6

मूल्य - 300/-

रचना - भारतीय ज्ञान परम्परा में शिक्षा के समाजशास्त्रीय आधार

सम्पादक - डॉ. दिनेश चन्द्र शर्मा

मुद्रक - श्रीनिवास प्रिन्टोग्राफिक्स, अजमेर

10. RENEWABLE ENERGY -SOURCES

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INTRODUCTION

Energy is essential in our daily lives. Most of our energy comes from burning fossil fuels like petroleum, coal and natural gas. Although the energy which we need Energy is essential in our daily lives. Most of our energy comes from burning must develop sustainable alternatives. Fossil fuels take millions of years to form for our daily lives is provided by these fuels, but there are several reasons why we with the earth. Once we use up our reserves of fossil fuels, we will be out in cold. unless we find fuel sources. In addition when these fossil fuels are burned, they release carbon dioxide and other gases into the atmosphere. Some of these gases pollute the air which is injurious to human health and contribute to climate change which threatens ecosystem.

A number of renewable resources like solar, wind, hydro power, tidal geo-thermal, heat and bio-fuels have potential energy supply for the better. These energy sources are called "renewable" because they never run out. Renewable energy sources are so named because aside from geothermal and tidal energies, they are replenished constantly by sunlight. Renewable energy has now become absolute necessity of the word. Renewable energy often provides energy in four important area: electricity generation, air and water heating/cooling, transportation and rural energy services. Uneven solar heating of the earth's surface causes wind Sunlight also fuels the water cycle, which is harnessed through hydro power, including hydroelectric dams and less invasive system that harness streams or ocean currents. Biofuels are grown using sunlight. Geothermal energy is considered renewable because radioactive decay on the earth's core which is not expected to cool down any time soon, produce it. The gravitational pull of sun

and moon causes the tides. The impact of these clean sources of energy on the environment is much lower than the conventional energy sources.

Non-renewable energy sources such as coal and petroleum, necessitate costly explorations for their procurement and become more expensive as their supplies dwindle and demand increases. Coal mining and petroleum exploration and refinement produce solid toxic waste. Burning of coal to produce electricity discharges arsenic and lead into surface water and release carbon dioxide, sulphur dioxide, oxides of nitrogen and mercury into the air. This kind of pollution leads to acid-rains, disrupts ecosystem and attacks the ozone layer.

BIOMASS ENERGY

Biomass is an exciting versatile renewable energy source. Biomass is a term used to describe all organic matter produced by photosynthesis, existing on the earth. They include all water and land-based vegetations and trees and all waste biomass such as municipal solid waste (MSW), municipal biosolids (Sewage) and animal wastes (manures), forestry and agricultural residues and certain type of industrial wastes. Through the process of photosynthesis, chlorophyll in plants captures the sun's energy by converting carbon dioxide from the air and water from the ground into carbohydrates i.e., complex compounds composed of carbon, hydrogen and oxygen. When these carbohydrates are burned, they turn back into carbon dioxide and water and release sun's energy they contain. Thus biomass functions as a sort of natural battery for storing solar energy.

The world's energy markets have relied heavily on the fossil fuels. Biomass is the only other naturally occurring energy containing carbon resource that is large enough in quantity to be used as a substitute for fossil fuels. Biomass constitutes an inexpensive renewable source that is available on global scale. It is such a widely utilised source of energy, probably due to its low cost and indigenous nature, that it accounts for almost 15% of the world's total energy supply and as much as 35% in developing countries, mostly for cooking and heating.

The exploitation of energy from biomass has played a key role in the evolution of mankind. Until relatively recently it was the only

form of energy which was usefully exploited by humans and is still the main source of energy for more than half the world's population for domestic energy needs. One of the simplest form of biomass is a basic open fire used to provide heat for cooking, warming water and warming the air in our home. More sophisticated technologies exist for extracting this energy and converting it into useful heat or power in an efficient way.

Resources of Biomass Energy

Biomass resources include primary, secondary and tertiary sources of biom

1 . Primary biomass resources: They are produced directly by photosynthesis and are taken directly from the land. They include per short rotation woody crops and herbaceous crops, the seeds of oil crops residues resulting from the harvesting of agricultural crops and forest thes (e.g., wheat straw, corn stover, tops, limbs and bark from trees).

2. Secondary biomass resources: It results from the processing of primary biomass. The processing is done either physically (production of saw dust Mills), chemically (black liquor from pulping processes) or biochemically (manure production by animals).

3. Tertiary biomass resources: They are post consumer residue straina 'including animal fats and greases, used vegetable oils, packaging wastes and construction and demolition debris."

Methods of Extraction of Biomass Energy

Biomass can be converted to thermal energy, liquid, solid and gaseous fuels and other chemical products through a variety of conversion processes. Generally the prominent bio-power technologies are comprised of direct combustion, co-firing gasification, pyrolysis, anaerobic digestion and fermentation.

(a) Direct Combustion: It is the simplest method for extracting energy from biomass. Industrial combustion facilities can burn many types of biomass fuels including wood, agricultural residues, wood pulping liquor, municipal solid waste etc. When biomass is burned, steam is produced which turns a turbine. The turbine, in turn drives a generator producing electricity. Only certain type of biomass materials

are used for direct combustion. If number of biomass type are used then large quantity of ash will be produced and ultimate result will be reduction in efficiency and cost.

Different designs of combustion boilers are available depending upon the application and biomass characteristics. The main options are to burn the biomass on a grate (fixed or moving), or to fluidize the biomass with the air or some other medium for complete burning.

2. Gasification: In this process gaseous fuel is produced for which solid fuel is exposed to high temperature in presence of limited oxygen.

The process produces a mixture of gas containing carbon dioxide, carbon monoxide, nitrogen, hydrogen and methane which is used to drive a high efficiency combined cycle gas turbine.

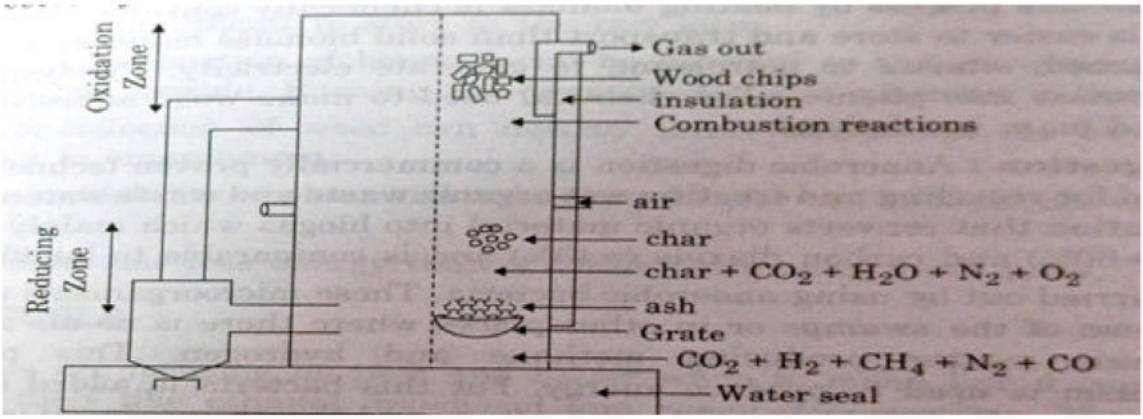
Advantage of this method over combustion method are:

* It is more convenient method.

* The fuel produce causes less pollution problems when burnt.

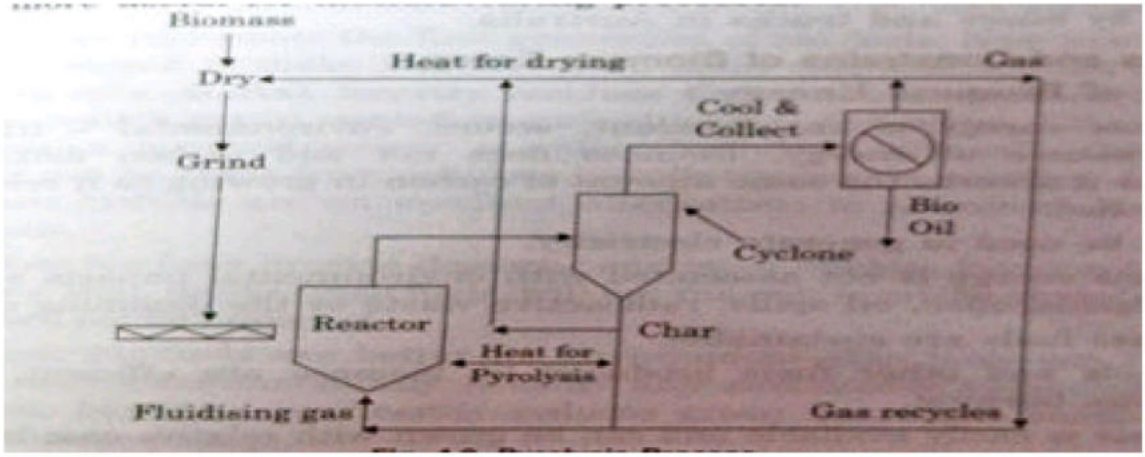
It can also produce synthesis gas or syngas which can be used to make hydrocarbons for replacing fossil fuels.

* Hydrogen itself is a potential fuel without much pollution which can conceivably substitute oils and petroleum in a foreseeable future



3. Pyrolysis: In this method when biomass is heated the volatile matter is driven off leaving behind the charcoal. The energy density of the original material is now doubled because charcoal, which is half the weight of the original biomass, contains the same amount of energy, making the fuel more transportable. The charcoal also burns at a much higher temperature, than the original biomass, making it

more useful for manufacturing processes.



4. Digestion: Anaerobic digestion is a commercially proven technology and of fermentation that converts organic material into biogas which mainly consists of methane (60%) and carbon dioxide (40%) and is comparable to landfill gas It is carried out by using anaerobic bacteria. These microorganisms usually dead organic matter producing methane and hydrogen. This property d at the bottom of the swamps or in other places where there is no air and feed on microorganism is used to produce energy. For this bacteria is added in digesths energy source. Using this method two third of the fuel energy of animal dung can be and the gas produced is used recovered. Similarly at the landfill sites having portion of household biomass wante methane gas formed by the decomposition of organic matter, could be collected

5. Fermentation: Fuel production from biomass by fermentation isextension process of fermentation procedure of sugars into ethanol. In this proc plant material from sugarcane wood fibre such as waste from wheat mill can be used. The ethanol thus produced is mixed with diesel to produce diesehol product used by buses and trucks in Australia.

Benefits and Constrains of Biomass Energy

Benefits of Biomass Energy:

1. Biomass energy is an abundant, secure, environmental friendly and renewable resource of energy. 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 fuel.

2. It can be used to generate electricity.

3. Biomass energy is not associated with environmental impacts such as acid rains, mine spoils, open, oil spills, radioactive waste or the damming of rivers.

4. Biomass fuels are sustainable.

5. Alcohols and other fuels produced by biomass are efficient, viable and relatively clean burning.

6. Biomass is easily available and can be grown with relative ease in all parts of the world.

BIO-FUELS

Scientists are focusing on new and better ways to make liquid transportable fuels or bio-fuels like ethanol, bio-diesel and renewable gasoline. They are also investigating the potential of producing power of bio-fuels. Ethanol is the most widely used bio-fuel in U.S. Ethanol E-10, a blend of 10% ethanol and 90% gasoline is used for running cars. Today most of ethanol in U.S. is made from corn. Corn ethanol is better than fossil fuels in several ways. Corn ethanol results in lower green house gas emission. The other advantage is that corn can be grown locally so the energy required for transportation of crude oil from other country is saved. In addition, one of the by products of corn based ethanol is Distiller's Dried Grains (DDG), a high protein animal feed being used in the U.S. and overseas.Corn ethanol represents the first generation of bio-fuels. Now new technologies have been developed to make bio fuels from many non-food sources such as crop residues (corn cobs, stalks), forestry residues (forest thinning, wood by-products), energy crops (switch grass), sorted municipal wastes and algae. Ethanol produced from cellulose, a non-food source, is called "cellulosic ethanol". Other types of bio-fuels that can be made from cellulose include renewable gasoline, diesel and jet fuel. Cellulosic biofuels are an excellent alternatives to petroleum based fuel for several reasons.

Cellulose bio-fuels provide domestic energy-Cellulose biomass is renewable resource that, unlike fossil fuels, will not run out. It can be grown every where and need not be imported.

* Cellulosic bio-fuels are better for environment-Bio fuels can be produced using more environmentally friendly and sustainable technologies. Use of cellulosic biomass significantly reduces green

house gas emissions, which cause climate change.

* Integrated bio-refineries support economic growth. A bio-refinery is a facility that combines biomass conversion processes and equipment to produce fuel power and value added chemicals from biomass. Because integrated markets.

Thus, based on the source of biomass, bio-fuels are classified broadly into two major categories:

(a) First generation bio-fuels: These are derived from sources such as sugarcane and corn starch. Sugar present in this biomass is fermented to produce bioethanol, an alcohol fuel which can be used directly in a fuel cell to produce electricity or serve as an additive to gasoline.

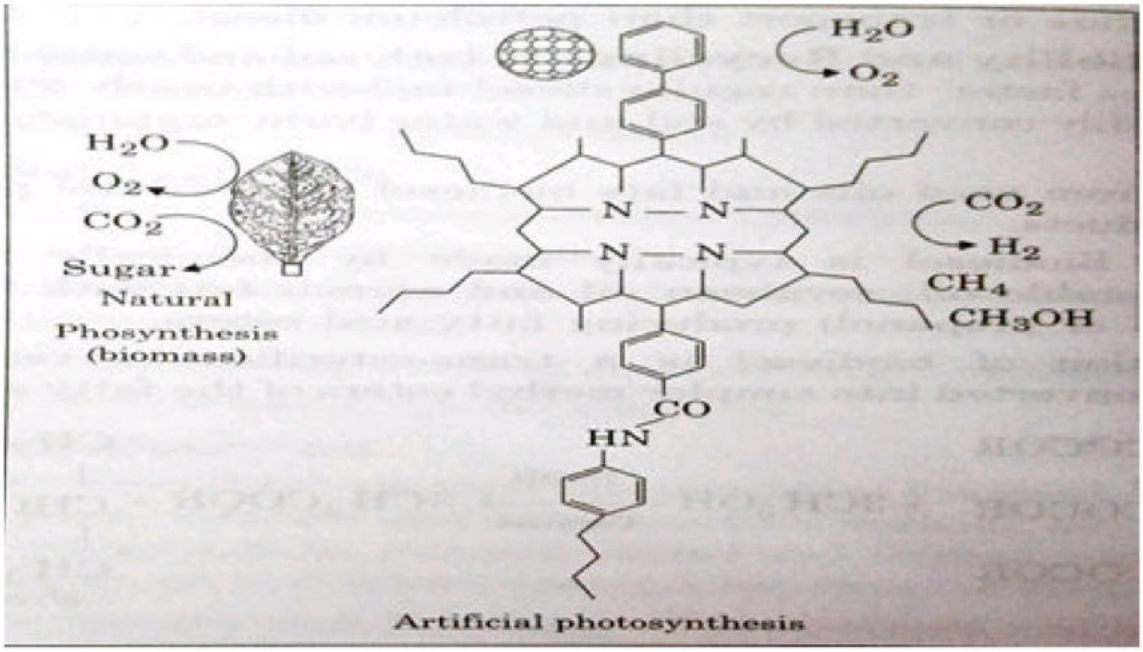
(b) Second generation bio-fuels: They use non-food based biomass sources such as agriculture and municipal waste. These bio-fuels mostly consist of lignocellulosic mass which is non-edible.

SOLAR ENERGY

Sun light is the most abundant source of potential energy on the planet. The enormous power that the sun continuously delivers to earth (1.2×10 terawatts), dwarfs every other source renewable or non-renewable. Further sun shine comes close to meeting the criteria of an ideal energy source including widespread utilization of solar energy does not cause air, heat or water pollution. Sunshine is intense and widely available in many parts of the world.availability, an unlimited supply and zero cost upto the point of collection. TheSolar power has received a lot of attention over the past several years due to growing interest in renewable energy and the increasing competitive prices of alternative energy sources. However

solar power generation itself is not new; it has been used for more than half acentury, mostly on small scale or for specialised purposes, such as generating allow it to become increasingly competitive with fossil fuels. electricity for spacecraft and satellites or for use in remote areas. Large scale slan energy generation was mostly developed in the 1970s and 1980s and considered as clean energy because of its lack of emissions. Continued growth is expected bece solar power has many environmental benefits and is decreasing in price, which will allow it to become increasingly competitive with

fossil fuels.



Solar Power as Heat Energy

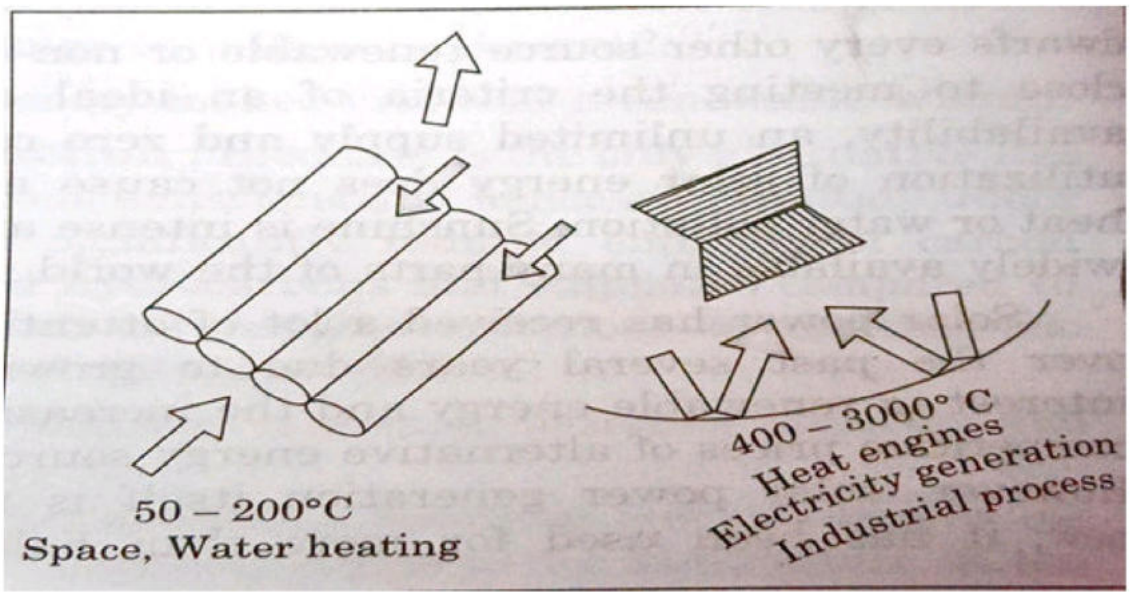
Solar power had been successfully used for heating of water for residential, commercial and industrial purposes. For this solar heaters have been developed Residential solar water heaters generally consists of roof mounted solar water collectors that directly heat water using sunlight. In indirect method, solar collectors increase the temperature of a heat

transfer material and pump it to a heat exchanger which creates the hot water.

At a more sophisticated level solar boilers have been developed. These boilers are located on tower where they receive heat from an array of parabolic mirrors. These mirrors receive concentrated sun light which generates steam that can be further used to generate electricity. Concentration of sunlight on parabolic trough produces temperature of 400°C and parabolic dishes can produce temperature of 650°C and higher. Using farm of mirrors temperature of 1500°C or more can be achieved, unconcentrated sunlight can bring the temperature of a fluid to about 200°C, enough to heat space and water in residential and commercial applications

The high temperature of solar power towers are attractive:

* for thermo-chemical water splitting and production of hydrogen.



* to power heat engines.

Solar Power as Fuel

Nature has devised a remarkable diverse set of pathways for converting solar photons into chemical fuels. An estimated 100TW of solar energy go into photosynthesis, the production of sugars and starches from water and carbon dioxide via endothermic reactions facilitated by catalysts. The overall conversionefficiency of plants is too low to satisfy the human demand for energy is photosynthesis the early stages are efficient.

$6CO,+6H_2O$ CHO+60

The inefficiency lies in the step in which carbon dioxide is reduced to fem carbohydrates. To improve the efficiency of photosynthesis based solar ful production, attempts have been made for breeding or genetically engineering planta to grow faster and produce more biomass, Artificial photosynthesis, uses inanimate components to convert sunlight inas chemical fuel. The components are not from the nature but the energy conversi routes are bio-inspired. Light harvesting and charge separation are accomplished by synthetic antennas linked to a porphyrin-based charge donar and a fulleren acceptor. The assembly is embedded in a artificial membrane, in the presence of quinones that acts as a proton shuttle.

Solar fuels can be created in an alternate, fully nonbiological way based on semiconductor solar cells rather than on photosynthesis.

Solar Power as Electrical Energy

Solar power is conversion of sunlight into electricity using solar cells. It is versatile means of generating electricity. It can be used for such purposes as heating water, air-conditioning homes and commercial buildings and powering street lights. Because sunlight is readily available almost every-where and does not require fuel or a connection to power-grid, solar power is particularly useful for suppling power to remote areas and to some portable devices.

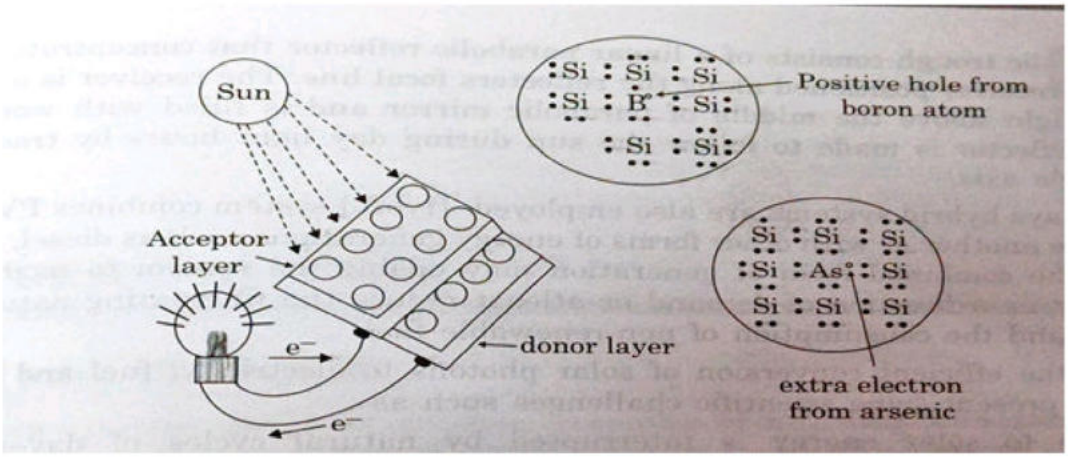
There are two basic methods for generating electricity from solar power:

(a) Photovoltaic (PV): They generate electricity directly from sunlight.

(b) Concentrated Solar Power (CSP): It converts sunlight into heat to produce steam, which is then fed through conventional steam-turbine generators to generate electricity.

Photovoltaic: These were initially solely used as a source of electricity for small and medium sized applications, from the calculator powered by a single cell to remote homes powered by an off-grid roof-top PV system.

Photovoltaic power uses solar cells that convert the energy of sunlight directly into electricity through the photovoltaic effect. The photovoltaic effect is a process by which light from the sun hits a solar cell and is absorbed by a semiconducting material such as crystalline silicon. The photons in the sunlight knock electrons loose from their atom, allowing them to flow freely through the material to produce direct electric current (DC) electricity. For household or utility use, an inverter must be used to convert the electricity to alternating current (AC).



Photovoltaic cells depend upon the special electronic properties of silicon atoms along with boron and arsenic atoms. The cell consists of two layers of silicon, a donor layer that is doped with about 1 part per million of arsenic atoms and an acceptor layer adped with about 1-part million of boron. Examination of the Lewis symbols of these three elements reveal that:

: Si:

: As:

B:

Silicon

arsenic boron

Substitution of a silicon atom with its four valence electrons in donor layer by an arsenic atom with its five valence electrons give a site with excess of one electron whereas substitution by boron atom with three valence electrons in acceptor layer gives a site termed as "hole" which is deficit of an electron. The surface of the donor layer in contact with an acceptor layer contains electrons which are attracted by the acceptor layer. When light shines on this area, the energy of photons of the light can push these electrons back to the donor layer, from which they can go through an external circuit back to the acceptor layer. This flow of electrons constitutes an electric current that can be used for energy.

The individual solar cells are arranged on to a solar panel. A new technology allows solar panels to be placed on a thin strip of backing, usually aluminium, and covered with a plastic film, which decreases the weight and cost of the solar panel. Several panels are arranged into an array.

Concentrated Solar Power (CSP)

Concentrated solar power, also called "concentrated solar thermal" uses lenses or mirrors and tracking systems to focus a large area of sunlight into small beam. It uses the heat sunlight to generate electricity from conventional steam driven turbines. For concentrating sun's radiation various technologies are employed out of which parabolic trough is well known.

A parabolic trough consists of a linear parabolic reflector that concentrates the light onto a positioned right above the middle of parabolic mirror and is filled with working fluid. The reflector is made to follow the sun during day light hours by tracking along a single axis.

Now-a-days hybrid systems are also employed. Hybrid system combines PV and CSP with one another or with other forms of energy generations such as diesel, wind or biogas. The combined form of generation may enable the system to modulate power output as a function of demand or atleast reduce the fluctuating nature of solar power and the consumption of non-renewable fuel.

Beyond the efficient conversion of solar photons to electricity, fuel and heat, solar energy present some scientific challenges such as:

* Access to solar energy is interrupted by natural cycles of day-night, cloudy-sunny and winter-summer variations.

* Solar fuel production automatically stores energy in chemical bonds. Electricity and heat are much more difficult to store.

Cost effective storage, even a fraction of peak demand for electricity or heat for 24 hrs is a talk well beyond present technology.

Solar conversion is a young science. Its major growth began in 1970s, spurred by the oil crisis. Solar energy science faces an equal rich future, with nano-science enabling the discovery of the guiding principles of photonic energy conversions and their use in the development of cost-competitive technologies.

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