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SOURCES OF ENERGY

INTRODUCTION

Energy is one of the most fundamental parts of our universe.

We use energy to do work. Energy lights our cities. Energy powers our vehicles, trains, planes and rockets. Energy warms our homes, cooks our food, plays our music, gives us pictures on television. Energy powers machinery in factories and tractors on a farm. Energy from the sun gives us light during the day. It dries our clothes when they're hanging outside on a clothes line. It helps plants grow. Energy stored in plants is eaten by animals, giving them energy. And predator animals eat their prey, which gives the predator animal energy. Everything we do is connected to energy in one form or another. Energy is defined as: "the ability to do work."

When we eat, our bodies transform the energy stored in the food into energy to do work. When we run or walk, we "burn" food energy in our bodies. When we think or read or write, we are also doing work. Cars, planes, light bulbs, boats and machinery also transform energy into work. Work means moving something, lifting something, warming something, lighting something. All these are a few of the various types of work. But where does energy come from? There are many sources of energy. Energy is an important part of our daily lives.

Various forms of energy includes: Electricity, Biomass Energy - energy from plants, Geothermal Energy, Fossil Fuels - Coal, Oil and Natural Gas, Hydro Power and Ocean Energy, Nuclear Energy, Solar Energy, Wind Energy.

In the present era at the one end energy occupies a prominent place in industrial development while at the other end energy is used as important component to improve the quality of human life. Therefore the development of any country is now measured in terms of per capita expenditure of energy. Per captia expenditure of the developed countries like America, Japan and Canada is 10 to 75 times more than the developing countries (like India, China). Due to continuously increasing population and increase in energy consumption, scientists and planners have been motivated to consume conventional sources of energy with planning and develop new sources of energy.

All forms of energy are stored in different ways, in the energy sources that we use every day. These sources are divided into two groups -- renewable (an energy source that can be replenished in a short period of time) and nonrenewable (an energy source that we are using up and cannot recreate in a short period of time). Renewable and nonrenewable energy sources can be used to produce secondary energy sources including electricity and hydrogen.

Renewable energy sources include solar energy, which comes from the sun and can be turned into electricity and heat. Wind, geothermal energy from inside the earth, biomass from plants, and hydropower and ocean energy from water are also renewable energy sources.

However, we get most of our energy from nonrenewable energy sources, which include the fossil fuels -- oil, natural gas, and coal. They're called fossil fuels because they were formed over millions and millions of years by the action of heat from the Earth's core and pressure from rock and soil on the remains (or "fossils") of dead plants and animals. Another nonrenewable energy source is the element uranium, whose atoms we split (through a process called nuclear fission) to create heat and ultimately electricity.

We use all these energy sources to generate the electricity we need for our homes, businesses, schools, and factories. Electricity "energizes" our computers, lights, refrigerators, washing machines, and air conditioners, to name only a few uses.

We use energy to run our cars and trucks. Both the gasoline used in our cars, and the diesel fuel used in our trucks are made from oil. The propane that fuels our outdoor grills and makes hot air balloons soar is made from oil and natural gas.

The demand for energy is increasing. The natural sources of energy like coal and petroleum products are fast depleting. Unless the increase in the production of energy is in the same proportion as its increasing consumption, there is bound to be a worldwide shortage of energy leading to a global energy crisis.

To overcome this energy crisis the development and use of alternative sources of energy is imperative. It is said that energy saved is energy produced. The growing demand of energy can be met by making a judicious use of available resources of energy.

While energy surrounds us in all aspects of life, the ability to harness it and use it for constructive ends as economically as possible is the challenge before mankind. Alternative energy refers to energy sources which are not based on the burning of fossil fuels or the splitting of atoms. The renewed interest in this field of study comes from the undesirable effects of pollution (as witnessed today) both from burning fossil fuels and from nuclear waste byproducts. Fortunately there are many means of harnessing energy which have less damaging impacts on our environment.

Good source of energy :

A good source of energy would be one which would do a large amount of work per unit volume or mass, be easily accessible, be easy to store and transport, and perhaps most importantly, be economical. So evaluation Criteria for source of energy are: Capital Costs, Operating Costs, Efficiency, Is it renewable? Energy Storage Requirements, Pollution, Environmental Modification, Levelized cost to the consumer, Feasibility on Large Scale, Unit Capacity .

ACTIVITY

- List four forms of energy that you use from morning, when you wake up, till you reach the school.
- From where do we get these different forms of energy ?
- Can we call these 'sources' of energy? Why or why not ?

ACTIVITY

- Consider the various options we have when we choose a fuel for cooking our food.
- What are the criteria you would consider when trying to categories something as a good fuel?
- Would your choice be different if you lived
  (a) in a forest? (b) in a remote mountain village or small island? (c) in New Delhi?
  (d) lived five centuries ago?
- How are the factors different in each case?

CONVENTIONAL SOURCES OF ENERGY

Fossil Fuels : Fossil fuels are hydrocarbon based natural resources that were formed over 300 hundred millions of years ago by the fossilization of prehistoric plants and animals. There are three major forms of fossil fuels: coal, oil and natural gas. We have learned to harness the energy released from these fossil fuels during combustion in order to meet our energy needs. Fossil fuels are a common source of energy we use everyday. They are used to generate the electricity that runs our household appliances, fuel the motors of our cars, and heat our homes. Fossil fuels are currently essential to providing the energy needs of our everyday lives.

Although the supplies of these fossil fuels are vast, they are not unlimited. Fossil fuels are depleting at an alarming rate. They are a nonrenewable resource and we are consuming vast quantities of them every day. Varying estimates project a complete depletion of oil and natural gas within anywhere from 40-100 years. Coal is the most abundant of the three and will last for about another 230 years. It is very likely that within our life times that one of these fossil fuels, if not more, will be completely consumed from the planet. And more important, the earth's atmosphere and biosphere may not survive the environmental impact of burning such enormous amounts of these fuels. Global warming is directly associated with the increase in greenhouse gases produced from the burning of fossil fuels. Carbon stored over millions of years is being released in a matter of decades, disrupting the earth's carbon cycle in unpredictable ways.

But fossil fuels are not the only source of energy, and burning fuel is not the only way to produce heat and motion. Renewable energy offers us a better way. Some energy sources are "renewable" because they are naturally replenished, because they can be managed so that they last forever, or because their supply is so enormous that they can never be meaningfully depleted by humans. Moreover, renewable energy sources have much smaller environmental impacts than fossil and nuclear fuels.

ACTIVITY

- Take a table-tennis ball and make three slits into it.
- Put semicircular fins cut out of a metal sheet into these slits.
- Pivot the tennis ball on an axle through its centre with a straight metal wire fixed to a rigid support. Ensure that the tennis ball rotates freely about the axle.
- Now connect a cycle dynamo to this.
- Connect a bulb in series.
- Direct a jet of water or steam produced in a pressure cooker at the fins (Fig.). What do you observe?

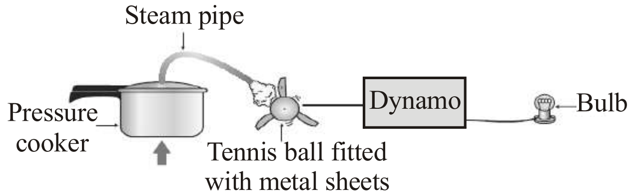


Figure : A model to demonstrate the process of thermoelectric production.

Oil : Oil was formed from the remains of animals and plants that lived millions of years ago in a marine (water) environment before the dinosaurs. Over the years, the remains were covered by layers of mud. Heat and pressure from these layers helped the remains turn into what we today call crude oil . The word "petroleum" means "rock oil" or "oil from the earth."

Crude oil is a smelly, yellow-to-black liquid and is usually found in underground areas called reservoirs. Scientists and engineers explore a chosen area by studying rock samples from the earth. Measurements are taken, and, if the site seems promising, drilling begins. Above the hole, a structure called a 'derrick' is built to house the tools and pipes going into the well. When finished, the drilled well will bring a steady flow of oil to the surface.

Oil fuels the modern world. No other substance can equal the enormous impact which the use of oil has had on so many people, so rapidly, in so many ways, and in so many places around the world.

Oil in its various refined derivative forms, such as gasoline, kerosene, and diesel fuel, has a unique combination of many desirable and useful characteristics. These include a current availability in abundance, a currently high net energy recovery, a high energy density, ease of transportation and storage, relative safety, and great versatility in end use. Oil is also useful as more than an energy source. It is the basis for the manufacture of petrochemical products including plastics, medicines, paints, and myriad other useful materials. Finally, the asphalt "bottoms" from refineries have converted millions of miles of muddy trails around the world into paved highways on which transport vehicles fueled by oil run.

But oil, like other fossil fuels, is a finite resource. True, there will always be oil in the Earth, but eventually the cost to recover what remains will be beyond the value of the oil. Also, a time will be reached when the amount of energy needed to recover the oil is equals or exceeds the energy in the recovered oil, at which point oil production becomes no more than a break-even, or a net energy loss situation.

THERMAL POWER PLANT

A thermal power station comprises all of the equipment and systems required to produce electricity by using a steam generating boiler fired with fossil fuels or biofuels to drive an electrical generator. Such power stations are most usually constructed on a very large scale and designed for continuous operation.

Electricity generation in thermal power plants includes firing of coal, gas or mazout, Steam is produced in a boiler, and it drives a turbine connected to an generator. Heat energy is converted to electric energy within the so-called steam cycle.

A thermal plant comprises several separate production units with specific size and power.

A conventional power plant consists of a boiler room, interposed machine room, machine room, electric power output, and auxiliary operations (coal loading, water treatment, water management, back fuel cycle, etc.). The following types of thermal power plants exist: condensating, whose main focus is generation of electricity, thermal plants whose main focus is combined generation of electricity and heat.

In a conventional condensating type thermal power plant, the electricity generation part is dominated by arrangement in production units. Every production unit of the power plant represents a separate generation entity a separate power plant. By the method of combustion, solid fuel firing boilers are classified into grate, granulation, fusion, and fluidized-bed type. Boilers firing solid and gas fuels are in addition to the above mentioned boilers.

Every power plant unit may be operated independently. The principle of operation is quite simple. Stockpile coal is moved by a bulldozer into an underground bunker, wherefrom it is taken by a coaling belt into a coal holder located at every boiler. The coal is gradually dried and ground to powder that is subsequently fired in the boiler. Pipe or membrane type evaporators are located in the boiler walls; there, water turns into steam and the steam generated (of a high temperature and pressure) is led to steam cylinder, wherefrom it is led through pre-heaters and postheaters via steam distribution pipes to turbine blades. The turbine is connected to a generator.

Turbine and electric generator comprise a single train – turbogenerator. In the turbogenerator, heat energy is converted into electric energy. Electric energy thus produced is led through a system of transformers and distribution grid to end-consumers. Having delivered its energy to turbine blades, the steam condensates in heat exchanger – condenser. Upon passing the turbine, the steam temperature and pressure get reduced. The steam changes its state and turns into water called condensate. Large quantities of cooling energy are needed for steam to condensate. Surface water from a stream or a reservoir is used for cooling. If there is a plenty of cooling water, flow-through system of cooling is used; circulation system of cooling with water being cooled in cooling towers is used for places with insufficient supply of cooling water.

On their way to the stack, flue gases produced during the firing of coal heat water in economizer, which is a heat exchanger for combustion gas. Cooled stack gases then pass through electrostatic filters where ash is caught, and continue to the stack.

To reduce nitrogen and sulfur oxides, desulfurization and denitrification equipment are installed to conventional boilers. For fluidized-bed boilers, desulfurization and denitrification is resolved directly by the boiler technology.

You may have heard about NTPC largest thermal power generating company of India.

In 1995, India had an installed electrical generating capacity of 81 gigawatts (GW), of which 73 percent was thermal. This is the world's sixth largest capacity and equal to that of France and the United Kingdom. India's power sector has grown at an average annual rate of 8.8 percent since 1950, when installed capacity was only 2.3 GW. About 85 percent of the country was electrified in 1995. Despite the dramatic increase in power generation capabilities, India has been unable to keep up with its domestic demand for electricity.India's electricity is generated overwhelmingly by coal (70 percent). Hydroelectricity ranks a distant second (about 25 percent), followed by natural gas, nuclear power, oil, and renewables.

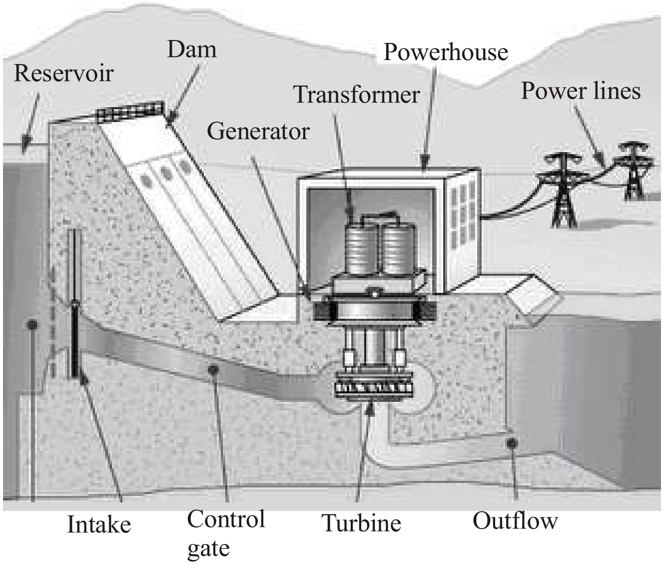
HYDRO POWER PLANTS

When it rains in hills and mountains, the water becomes streams and rivers that run down to the ocean. The moving or falling water can be used to do work. Energy, you'll remember is the ability to do work. So moving water, which has kinetic energy, can be used to make electricity.

For hundreds of years, moving water was used to turn wooden wheels that were attached to grinding wheels to grind (or mill) flour or corn. These were called grist mills or water mills.

Hydro means water. Hydro-electric means making electricity from water power. In fact, humans have been using the energy in moving water for thousands of years. Today hydroelectric power is the largest source of renewable power worldwide. A quarter of our energy requirement in India is met by hydro power plants.

Hydroelectric power uses the kinetic energy of moving water to make electricity. Dams can be built to stop the flow of a river. Water behind a dam often forms a reservoir The water behind the dam flows through the intake and into a pipe called a penstock.



The principle of the operation of hydroelectric power plants is conversion of mechanical into electric energy. Water stream passes stable turbine vanes and thus directed water stream hits water turbine blades of the turbine runner curved in an opposite direction; in this way, the blades are turned, and receive mechanical energy from water. Mechanical energy of water is converted into mechanical energy of the shaft, and subsequently to electric energy in electric generators. Electric generators of hydroelectric power plants convert mechanical energy to electric energy with a high efficiency. In synchronous generators, electric energy is generated by inducing rotating magnetic field of the rotor into stable generator stator coil. To generate magnetic field of the rotor, excitation direct current is needed generated in generator exciter.

Hydroelectric generation can also work without dams, in a process known as diversion, or run-of-the-river. Portions of water from fast-flowing rivers, often at or near waterfalls, can be diverted through a penstock to a turbine set in the river or off to the side. The generating stations at Niagara Falls are an example of diversion hydropower. Another run-of-the-river design uses a traditional water wheel on a floating platform to capture the kinetic force of the moving river. While this approach is inexpensive and easy to implement, it doesn't produce much power. The entire Amazon River, if harnessed this way, would produce only 650 MW of power.

Another type of hydropower, though not a true energy source, is pumped storage. In a pumped storage plant, water is pumped from a lower reservoir to a higher reservoir during off-peak times, using electricity generated from other types of energy sources. When the power is needed, it is released back into the lower reservoir through turbines. Inevitably, some power is lost, but pumped storage systems can be up to 80 percent efficient.. Future increases in pumped storage capacity could result from the integration of hydropower and wind power technologies. Researchers believe that hydropower may be able to act as a battery for wind power by storing water during high wind periods.

Although an inexpensive and nonpolluting energy resource, the environmental damage caused hydropower can be serious. The most obvious effect is that fish are blocked from moving up and down the river, but there are many more problems.

When a dam is constructed, a river habitat is replaced by a lake habitat. While this may not sound so bad -- fish and birds like lakes, too it can cause a number of environmental problems. Dams can create large reservoirs submerging what used to be dry land, producing many problems.. Population density is typically higher along rivers, leading to mass dislocation of urban centers.Opposition to the construction of Tehri Dam on the river Ganga and Sardar Sarovar project on the river Narmada are due to such problems.

Wildlife habitats destroyed by reservoirs can be especially valuable. Another problem can occur when the land area behind the dam is flooded without proper preparation. Later, as the plants and trees that were submerged began to rot, they reduced the oxygen content of the water, killing off the plants and fish in the water. Moreover, the rotting plants gave off large quantities of methane, a powerful global warming gas.

Impoundments used for hydropower can cause many other effects on water quality and aquatic life. Rivers and lakes can be filled with sediment from erosion. Water falling over spillways can force air bubbles into the water, which can be absorbed into fish tissue, ultimately killing the fish. By slowing down rivers, the water can become stratified, with warm water on top and cold water on the bottom. Since the cold water is not exposed to the

surface, it loses its oxygen and becomes uninhabitable for fish.
The risk of a dam breaking should also not be ignored. The great Johnstown flood in Pennsylvania was the result of a dam break (although not a hydroelectric dam); 2,000 people were killed. In northern India and Nepal, in the Himalayas, huge hydroelectric projects are planned that would create large reservoirs in a geographically unstable region. Frequent earthquakes make the dam a risky venture for heavily populated areas downstream. This is compounded by the fear that large, heavy reservoirs would put additional pressure on the plates in the region, causing even more earthquakes. Finally, breakage could also result from war or terrorism, as dams have been considered potential military targets in the past. The environmental and social effects of hydropower can be immense. But while hydropower has its problems, it can still be a safe and sustainable source of electricity if proper measures are taken. By upgrading and improving the equipment at plants, by increasing fish-friendly efforts at dams, and by improving run-of-the-river turbine technology, it may be possible to reduce the environmental effects of hydropower. Nonetheless, remediation may be impossible at some sites, and wild rivers should be unshackled.
It is also important to compare the environmental effects of hydropower with alternatives. The damage to aquatic habitat from dams may be significant, but acid rain, nitrogen deposition, and thermal pollution from coal plants also lead to aquatic damage, as well as to air pollution and global warming

IMPROVEMENTS IN THE TECHNOLOGY FOR USING CONVENTIONAL SOURCES OF ENERGY

Bio-Mass : Biomass is matter usually thought of as garbage. Some of it is just stuff lying around -- dead trees, tree branches, yard clippings, left-over crops, wood chips and bark and sawdust from lumber mills. It can even include used tires and livestock manure. Your trash, paper products that can't be recycled into other paper products, and other household waste are normally sent to the dump. Your trash contains some types of biomass that can be reused. Recycling biomass for fuel and other uses cuts down on the need for "landfills" to hold garbage.
This stuff nobody seems to want can be used to produce electricity, heat, compost material or fuels. Composting material is decayed plant or food products mixed together in a compost pile and spread to help plants grow
A similar thing can be done at animal feed lots. In places where lots of animals are raised, the animals - like cattle, cows and even chickens - produce manure. When manure decomposes, it also gives off methane gas similar to garbage. This gas can be burned right at the farm to make energy to run the farm.
Biomass is a renewable energy source because the energy it contains comes from the sun. 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, complex compounds composed of carbon, hydrogen, and oxygen. When these carbohydrates are burned, they turn back into carbon dioxide and water and release the sun's energy they contain. In this way, biomass functions as a sort of natural battery for storing solar energy. As long as biomass is produced sustainably—with only as much used as is grown the battery will last indefinitely.
A number of noncombustion methods are available for converting biomass to energy. These processes convert raw biomass into a variety of gaseous, liquid, or solid fuels that can then be used directly in a power plant for energy generation. The carbohydrates in biomass, which are comprised of oxygen, carbon, and hydrogen, can be broken down into a variety of chemicals, some of which are useful fuels. This conversion can be done in three ways:
(1)Thermochemical : When plant matter is heated but not burned, it breaks down into various gases, liquids, and solids. These products can then be further processed and refined into useful fuels such as methane and alcohol. Biomass gasifiers capture methane released from the plants and burn it in a gas turbine to produce electricity. Another approach is to take these fuels and run them through fuel cells, converting the hydrogen-rich fuels into electricity and water, with few or no emissions.
(2) Biochemical : Bacteria, yeasts, and enzymes also break down carbohydrates. Fermentation, the process used to make wine, changes biomass liquids into alcohol, a combustible fuel. A similar process is used to turn corn into grain alcohol or ethanol, which is mixed with gasoline to make gasohol. Also, when bacteria break down biomass, methane and carbon dioxide are produced. This methane can be captured, in sewage treatment plants and landfills, for example, and burned for heat and power.

(3) Chemical : Biomass oils, like soybean and canola oil, can be chemically converted into a liquid fuel similar to diesel fuel, and into gasoline additives. Cooking oil from restaurants, for example, has been used as a source to make "biodiesel" for trucks. (A better way to produce biodiesel is to use algae as a source of oils.)

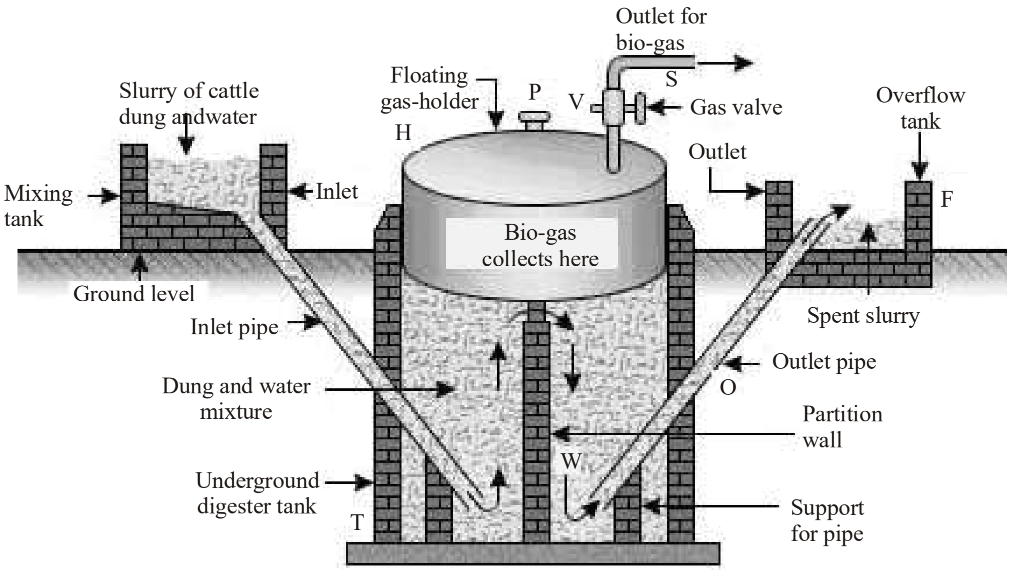
Bio gas : Bio gas is made from organic waste matter after it is decomposed. The decomposition breaks down the organic matter, releasing various gases. The main gases released are methane, carbon dioxide, hydrogen and hydrogen sulphide. Bacteria carry out the decomposition or fermentation. The conditions for creating bio gas has to be anaerobic that is without any air and in the presence of water. The organic waste matter is generally animal or cattle dung, plant wastes, etc. These waste products contain carbohydrates, proteins and fat material that are broken down by bacteria. The waste matter is soaked in water to give the bacteria a proper medium to grow. Absence of air or oxygen is important for decomposition because bacteria then take oxygen from the waste material itself and in the process break them down.

There are two types of bio gas plants that are used in India. These plants mainly use cattle dung called “gobar” and are hence called gobar gas plant. Generally a slurry is made from cattle dung and water, which forms the starting material for these plants.

The two types of bio gas plants are :

1. Floating gas-holder type 2. Fixed dome type

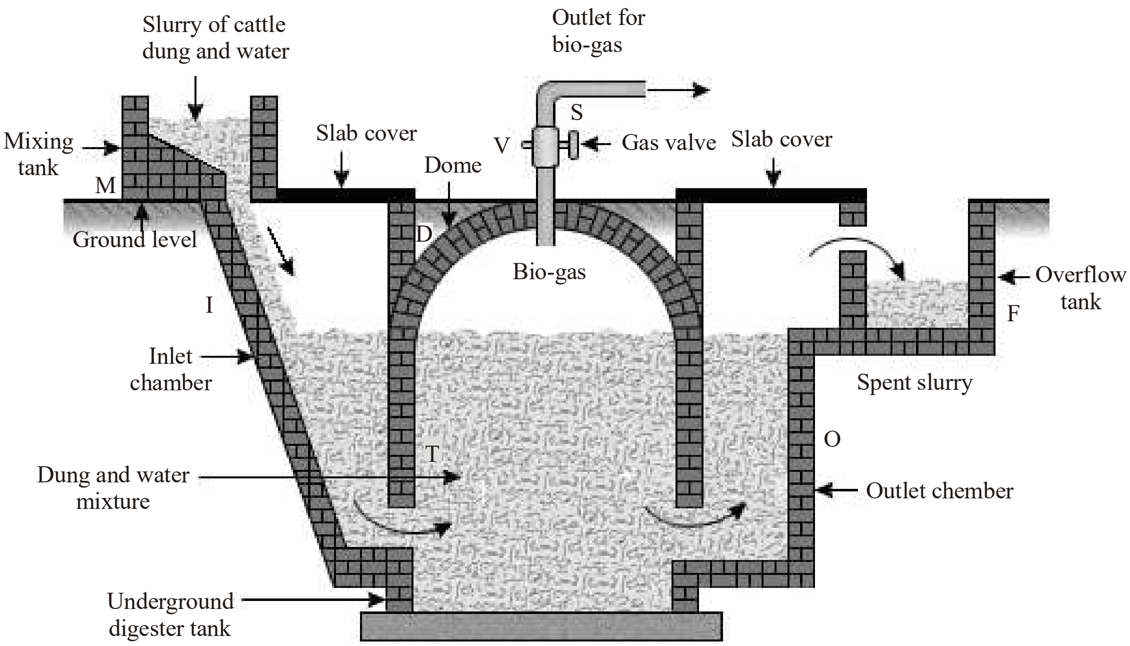
Floating gas holder type of plant : The diagram below shows the details of a floating gas holder type of bio gas plant.



Floating gas-holder type bio-gas plant

A well is made out of concrete. This is called the digester tank T. It is divided into two parts. One side has the inlet, from where slurry is fed to the tank. The tank has a cylindrical dome H made of stainless steel that floats on the slurry and collects the gas generated. Hence the name given to this type of plant is floating gas holder type of bio gas plant. The slurry is made to ferment for about 50 days. As more gas is made by the bacterial fermentation, the pressure inside H increases. The gas can be taken out through outlet pipe V. The decomposed matter expands and overflows into the next chamber in tank T. This is then removed by the outlet pipe to the overflow tank and is used as manure for cultivation purposes.

Fixed dome type of plant : The diagram below shows the details of a fixed dome type of bio gas plant.



Fixed-dome type bio-gas plant

A well and a dome are made out of concrete. This is called the digester tank T. The dome is fixed and hence the name given to this type of plant is fixed dome type of bio gas plant. The function of the plant is similar to the floating holder type bio gas plant. The used slurry expands and overflows into the overflow tank F.
Bio gas is used as cooking fuel as it contains up to 75% methane and burns without smoke, has high calorific value, can be piped into kitchens directly from a plant and is cheaper in cost.
Bio gas can be used to run electric engines such as pumps, as they cause less air pollution.
Bio gas can be used for street lighting as they do not cause any smoke and the illumination obtained can be made to be quite adequate

Environmental Benefits : Biomass energy brings numerous environmental benefits—reducing air and water pollution, increasing soil quality and reducing erosion, and improving wildlife habitat.
Using biomass can help reduce global warming compared to a fossil fuel-powered plant. Plants use and store carbon dioxide (CO_2) when they grow. CO_2 stored in the plant is released when the plant material is burned or decays. By replanting the crops, the new plants can use the CO_2 produced by the burned plants. So using biomass and replanting helps close the carbon dioxide cycle. However, if the crops are not replanted, then biomass can emit carbon dioxide that will contribute toward global warming.
So, the use of biomass can be environmentally friendly because the biomass is reduced, recycled and then reused. Today, new ways of using biomass are still being discovered. One way is to produce ethanol, a liquid alcohol fuel. Ethanol can be used in special types of cars that are made for using alcohol fuel instead of gasoline. The alcohol can also be combined with gasoline. This reduces our dependence on oil - a non-renewable fossil fuel.

WIND ENERGY

Along with sun, it was the air, which showed man its power. Even before the solar energy, it was the wind energy that man used for his work. Initially, it was used in two main ways; to drive wind mills on land and to drive sailing vessels at sea. The first use of windmills were to grind foods grains and to run pumps to irrigate.
Farmers have been using wind energy for many years to pump water from wells using windmills. Now with the advancement of science and technology, we have windmills generating electricity. Naturally, now this energy can be used for many more works.

Wind is simple air in motion. It is caused by the uneven heating of the earth's surface by the sun. Since the earth's surface is made of very different types of land and water, it absorbs the sun's heat at different rates.
During the day, the air above the land heats up more quickly than the air over water. The warm air over the land expands and rises, and the heavier, cooler air rushes in to take its place, creating winds. At night, the winds are reversed because the air cools more rapidly over land than over water.
In the same way, the large atmospheric winds that circle the earth are created because the land near the earth's equator is heated more by the sun than the land near the North and South Poles.

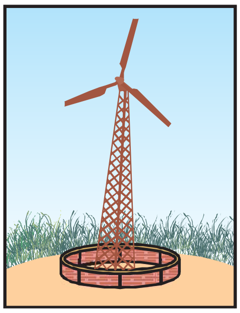
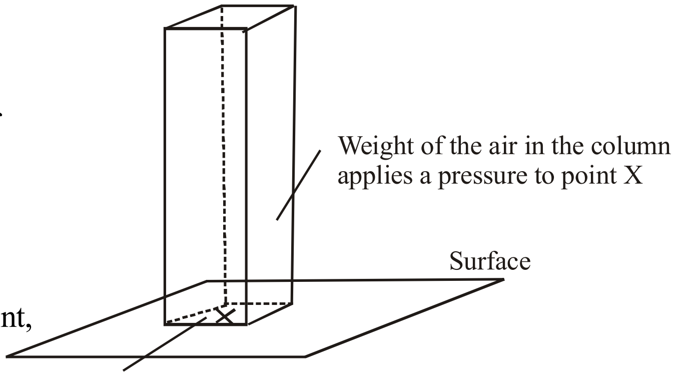


Figure : A windmill

What makes the wind blow?

Wind is the response of the atmosphere to uneven heating conditions. This creates pressure differences in the atmosphere causing the wind to blow from regions of high atmospheric pressure to low atmospheric pressure. The larger the pressure difference the greater the wind velocity.
Air pressure represents the amount of atmosphere that is pressing down on the surface of the earth at some point, as shown here:



Pressure differences yield wind (bulk motion of the air).
Wind can be used to do work. The kinetic energy of the wind can be changed into other forms of energy, either mechanical energy or electrical energy. Infact Wind energy is the fastest growing source of electricity in the world. Harnessing the wind is one of the cleanest, most sustainable ways to generate electricity. Wind power produces no toxic emissions and none of the heat trapping emissions that contribute to global warming. This, and the fact that wind power is one of the most abundant and increasingly cost-competitive energy resources, makes it a viable alternative to the fossil fuels that harm our health and threaten the environment.
Blowing wind spins the blades on a wind turbine - just like a large toy pinwheel. This device is called a wind turbine and not a windmill. A windmill grinds or mills grain, or is used to pump water.
The blades of the turbine are attached to a hub that is mounted on a turning shaft. The shaft goes through a gear transmission box where the turning speed is increased. The transmission is attached to a high speed shaft which turns a generator that makes electricity. If the wind gets too high, the turbine has a brake that will keep the blades from turning too fast and being damaged.
In order for a wind turbine to work efficiently, wind speeds usually must be above 12 to 14 miles per hour. Wind has to be this speed to turn the turbines fast enough to generate electricity. The turbines usually produce about 50 to 300 kilowatts of electricity each. A kilowatt is 1,000 watts (kilo means 1,000). You can light ten 100 watt light bulbs with 1,000 watts. So, a 300 kilowatt (300,000 watts) wind turbine could light up 3,000 light bulbs that use 100 watts.
Once electricity is made by the turbine, the electricity from the entire wind farm is collected together and sent through a transformer. There the voltage is increase to send it long distances over high power lines.
The wind resource–how fast it blows, how often, and when–plays a significant role in its power generation cost. The power output from a wind turbine rises as a cube of wind speed. In other words, if wind speed doubles, the power output increases eight times. Therefore, higher-speed winds are more easily and inexpensively captured.
Wind speeds are divided into seven classes–with class one being the lowest, and class seven being the highest. A wind resource assessment evaluates the average wind speeds above a section of land (usually 50 meters high), and assigns that area a wind class. Wind turbines operate over a limited range of wind speeds. If the wind is too slow,

they won't be able to turn, and if too fast, they shut down to avoid being damaged. Wind speeds in classes three (6.7 – 7.4 meters per second (m/s)) and above are typically needed to economically generate power. Ideally, a wind turbine should be matched to the speed and frequency of the resource to maximize power production.
The more the wind blows, the more power will be produced by wind turbines. But, of course, the wind does not blow consistently all the time. The term used to describe this is "capacity factor," which is simply the amount of power a turbine actually produces over a period of time divided by the amount of power it could have produced if it had run at its full rated capacity over that time period.
A more precise measurement of output is the "specific yield." This measures the annual energy output per square meter of area swept by the turbine blades as they rotate. Overall, wind turbines capture between 20 and 40 percent of the energy in the wind. So at a site with average wind speeds of seven m/s, a typical turbine will produce about 1,100 kilowatt-hours (kWh) per square meter of area per year. If the turbine has blades that are 40 meters long, for a total swept area of 5,029 square meters, the power output will be about 5.5 million kWh for the year. An increase in blade length, which in turn increases the swept area, can have a significant effect on the amount of power output from a wind turbine.

ALTERNATIVE OR NON-CONVENTIONAL SOURCES OF ENERGY

Solar energy (power from the sun is free and inexhaustible)

The energy obtained from the sun is called solar energy. The inner temperature of the sun is very high (10^7k). At this high temperature the nucleus of lightest gas hydrogen atoms fuse to convert into heavy nucleus of helium. A lot of energy is released in this nuclear reaction. Sun is the biggest source of energy. Energy of the sun reaching every year on earth is about 1.6×10^8 KWH (Kilo watt hour). Value of energy used by all the beings living on the earth is 7×10^{13} KWH per year. It is clear that every year energy received from the sun is 2000 times more than its annual consumption. Man has been using solar energy in making salt from the sea water, drying of clothes, heating water and in form of light. In the present technological era possibilities of more broad based utilisation of solar energy are bring explored. Solar energy is tapped for heat and electricity generation. Solar energy is used in solar cooker, solar heater and solar cells. We know today, that the sun is simply our nearest star. Without it, life would not exist on our planet. We use the sun's energy every day in many different ways.
When we hang laundry outside to dry in the sun, we are using the sun's heat to do work drying our clothes.
Plants use the sun's light to make food. Animals eat plants for food, decaying plants hundreds of millions of years ago produced the coal, oil and natural gas that we use today. So, fossil fuels is actually sunlight stored millions and millions of years ago.
Indirectly, the sun or other stars are responsible for all our energy. Even nuclear energy comes from a star because the uranium atoms used in nuclear energy were created in the fury of a nova - a star exploding.
Solar energy is one the most resourceful sources of energy for the future. One of the reasons for this is that the total energy we receive each year from the sun is around 35,000 times the total energy used by man. However, about 1/3 of this energy is either absorbed by the outer atmosphere or reflected back into space (a process called albedo)
Solar power, or energy from the Sun, is a free, abundant, and nonpolluting source of energy. This vast, clean energy resource represents a viable alternative to the fossil fuels that currently pollute our air and water, threaten our public health, and contribute to global warming.
It is estimated that during a year India receives the energy equivalent to more than 5,000 trillion kWh. Under clear (cloudless) sky conditions, the daily average varies from 4 to 7 kWh/m^2.
The solar energy per unit time reaching unit area at outer edge of the earth's atmosphere exposed perpendicularly to the rays of the Sun at the average distance between the Sun and earth is known as the solar constant. It is estimated to be approximately 1.4 kJ per second per square metre or 1.4 kW/m^2
Solar energy can be used to heat buildings and water and to produce electricity. However, the Sun does not always shine, and the process of collecting solar energy and storing it for use at night and on cloudy days is difficult and expensive.

Solar energy systems can be either passive or active. In a passive solar heating system, a building captures and stores the Sun's heat because of the way it is designed, the materials it is made of, or the heat-absorbing structures it possesses. An example of a passive system is a building with large windows facing south (that allow sunlight to enter) and with thick walls that store heat and release it at night.

Active solar energy systems use pumps or fans to circulate heat obtained by solar collectors. A solar collector is a device that absorbs the energy of the Sun and converts it to heat for heating buildings and water. Flat-plate collectors are mounted to the roofs of buildings and used for space heating. They are made of a heat-absorbing plate, such as aluminum or copper, covered by glass or plastic. Water or air circulating in the collector absorbs heat from the plate and is carried to a heat storage tank. The stored heat is circulated or blown over cold rooms using pumps or fans. A conventional heating system is used as a backup when solar heat is not available. Solar heating of water is accomplished using a collector, a hot water storage tank, and a pump to circulate water.

Solar power plants using energy from the Sun to produce steam for driving turbines to generate electricity could potentially replace fuel-driven power plants, producing energy without any environmental hazards.

ACTIVITY

- Find out from your grand-parents or other elders –
  (a) how did they go to school ?
  (b) how did they get water for their daily needs when they were young?
  (c) what means of entertainment did they use?
- Compare the above answers with how you do these tasks now.
- Is there a difference? If yes, in which case more energy from external sources is consumed?

ACTIVITY

- Take two conical flasks and paint one white and the other black. Fill both with water.
- Place the conical flasks in direct sunlight for half an hour to one hour.
- Touch the conical flasks. Which one is hotter? You could also measure the temperature of the water in the two conical flasks with a thermometer.
- Can you think of ways in which this finding could be used in your daily life?

SOLAR CELLS OR PHOTOVOLTAIC ENERGY

Solar cell is such device which converts solar energy into electric energy. Solar cells are also known as photo voltaic cell (PV cell) because it works on the principle of photo-voltaic effect.

Solar cells can be found on many small appliances, like calculators, and even on spacecraft.. They are made of silicon, a special type of melted sand. Silicon is abundant in nature but availability of the special grade silicon for making solar cells is limited.

When sunlight strikes the solar cell, electrons are knocked loose. They move toward the treated front surface. An electron imbalance is created between the front and back.

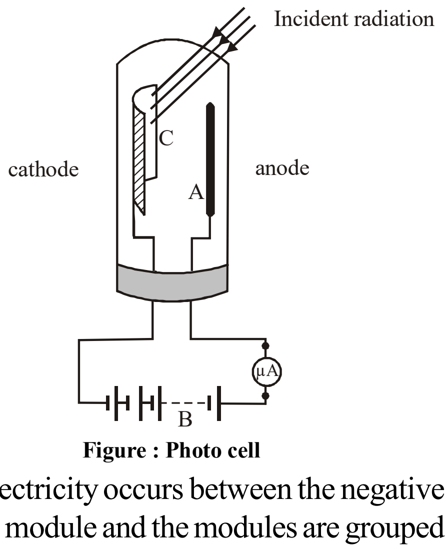


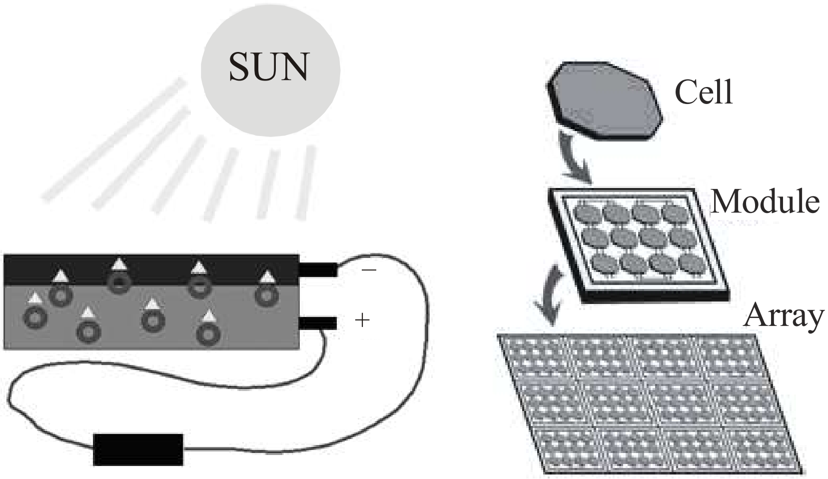
Figure : Photo cell

When the two surfaces are joined by a connector, like a wire, a current of electricity occurs between the negative and positive sides. These individual solar cells are arranged together in a PV module and the modules are grouped together in an array.

The electrical energy from solar cells can then be used directly. It can be used in a home for lights and appliances. It can be used in a business. Solar energy can be stored in batteries to light a roadside billboard at night. Or the energy can be stored in a battery for an emergency roadside cellular telephone when no telephone wires are around.

Some experimental cars also use PV cells. They convert sunlight directly into energy to power electric motors on the car.

The principal advantages associated with solar cells are that they have no moving parts, require little maintenance and work quite satisfactorily without the use of any focussing device. Another advantage is that they can be set up in remote and inaccessible hamlets or very sparsely inhabited areas in which laying of a power transmission line may be expensive and not commercially viable. Artificial satellites and space probes like Mars orbiters use solar cells as the main source of energy. Radio or wireless transmission systems or TV relay stations in remote locations use solar cell panels.



Applications of photo electric cells :

1. Photocells are used in television cameras for telecasting scenes and photo telegraphy
2. Photocells are used in reproduction of sound in motion pictures.
3. Photocells are used to switch on and off the street lights automatically.
4. These are used to obtain electric energy from sun light during space travel.
5. These are used to control temperature in furnaces and chemical reactions.
6. These are used in fire and burglar's alarm, to open and close the doors automatically and in counting devices
7. These are used to compare illuminating power of two sources.
8. Photocells are used to detect opacity of solids, defects in materials etc.

Solar Thermal Concentrating Systems : By using mirrors and lenses to concentrate the rays of the sun, solar thermal systems can produce very high temperatures—as high as 3,000 degrees Celsius. This intense heat can be used in industrial applications or to produce electricity.

Solar concentrators come in three main designs: parabolic troughs, parabolic dishes, and central receivers. The most common is parabolic troughs—long, curved mirrors that concentrate sunlight on a liquid inside a tube that runs parallel to the mirror. The liquid, at about 300 degrees Celsius, runs to a central collector, where it produces steam that drives an electric turbine.

Parabolic dish concentrators are similar to trough concentrators, but focus the sunlight on a single point. Dishes can produce much higher temperatures, and so, in principle, should produce electricity more efficiently. But because they are more complicated, they have not succeeded outside of demonstration projects.

A more promising variation uses a stirling engine to produce power. Unlike a car's internal combustion engine, in which gasoline exploding inside the engine produces heat that causes the air inside the engine to expand and push out on the pistons, a stirling engine produces heat by way of mirrors that reflect sunlight on the outside of the engine. These dish-stirling generators produce about 30 kilowatts of power, and can be used to replace diesel generators in remote locations.

The third type of concentrator system is a central receiver.. The intense heat boils water, producing steam that drives a generator at the base of the tower..
To date, the parabolic trough has had the greatest commercial success of the three solar concentrator designs.

Solar Cooker : A solar cooker is a device that uses the energy in sunlight to generate sufficient temperatures to be able to cook food. Solar cookers can be used to perform most cooking tasks, such as baking cakes, roasting meat and vegetables, boiling soups, etc.
The principle of using the sun to cook food is not a new concept. Swiss naturalist Horace de Saussure was known to have been experimenting with solar cookers as early as 1767. Three basic solar cooker designs exist:

- Parabolic Reflector • Box Cookers • Panel Cookers

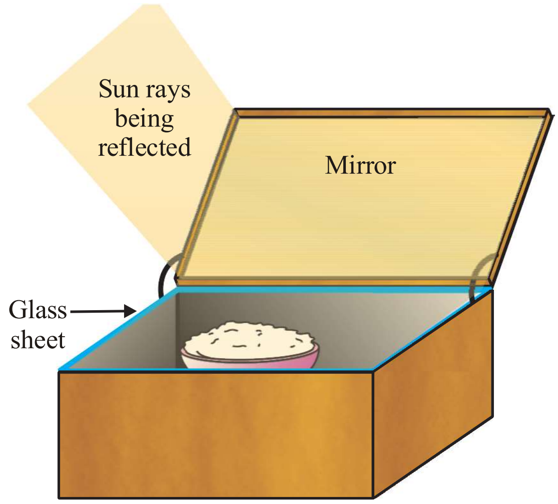


Figure : A solar cooker

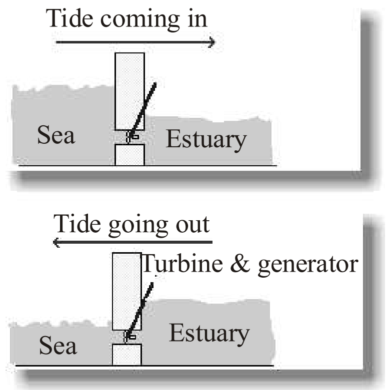
Parabolic Reflectors : Two types of parabolic reflectors are available: trough and dish. Parabolic cookers focus the light from the sun at or along a focal axis, Dish cookers focus the sun onto one point and cook in a similar way to single hotplates whilst trough designs are similar to rotisseries and are best used for cooking long thin foods such as sausages.

Box Cookers : As higher temperatures are often required for the cooking of food than would normally be obtained with flat plate collectors used in water heating, box cookers usually have reflectors to increase the amount of radiation that enters the collector.

Panel Cookers : A relatively new style of solar cooker, a panel cooker consists of a number of flat reflection panels that direct light onto a container to be cooked .To retain the heat, the cooking dish is placed within a plastic bag or under a glass bowl.

ENERGY FROM THE SEA

Tidal Energy (Extracts energy from the kinetic energy of the earth-moon-sun system)
Tide arise due to the gravitational pull of mainly the moon on the spinning earth., The tide moves a huge amount of water twice each day, and harnessing it could provide a great deal of energy. Although the energy supply is reliable and plentiful, converting it into useful electrical power is not easy.
Tidal energy has been used since about the 11th Century, when small dams were built along ocean estuaries and small streams. the tidal water behind these dams was used to turn water wheels to mill grains.
The simplest generation system for tidal plants involves a dam, known as a barrage, across an inlet. Sluice gates on the barrage allow the tidal basin to fill on the incoming high tides and to empty through the turbine system on the outgoing tide, also known as the ebb tide. There are two-way systems that generate electricity on both the incoming and outgoing tides.
Tidal energy is renewable. The tides will continue to ebb and flow, and the energy is there for the taking.



A major drawback of tidal power stations is that they can only generate when the tide is flowing in or out - in other words, only for 10 hours each day. However, tides are totally predictable, so we can plan to have other power stations generating at those times when the tidal station is out of action.

Tidal fences can also harness the energy of tides. A tidal fence has vertical axis turbines mounted in a fence. All the water that passes is forced through the turbines. They can be used in areas such as channels between two landmasses. Tidal fences have less impact on the environment than tidal barrages although they can disrupt the movement of large marine animals. They are cheaper to install than tidal barrages too.

Advantages

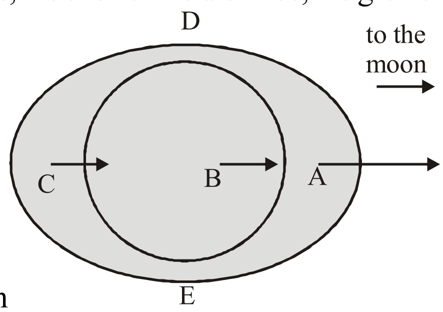
- Once you've built it, tidal power is free.
- It produces no greenhouse gases or other waste.
- It needs no fuel.
- It produces electricity reliably.
- Not expensive to maintain.
- Tides are totally predictable.
- Offshore turbines and vertical-axis turbines are not ruinously expensive to build and do not have a large environmental impact.

Disadvantages :

- A barrage across an estuary is very expensive to build, and affects a very wide area - the environment is changed for many miles upstream and downstream. Many birds rely on the tide uncovering the mud flats so that they can feed. There are few suitable sites for tidal barrages.
- Only provides power for around 10 hours each day, when the tide is actually moving in or out.

Why are there two high tides and two low tides per day?

Tides exist as the earth is affected by the non-uniform gravitational force from the moon. What is a non-uniform gravitational force? According to Newton's Law of universal gravitation, the gravitational force between two objects is inversely proportional to the square of the distance between them. That is, the shorter the distance, the greater the force, and the longer the distance, the weaker the force.



Please look at Fig. Point A experiences a greater lunar gravitational force than Point B (the earth's centre). Seawater is being attracted naturally towards the moon. A high tide is formed. Point C experiences a smaller lunar gravitational force than Point B, therefore the water level is higher here relative to Point B. Thus there are high tides at Point A and Point C, while the water levels at Point D and Point E are lower, that is, there are low tides. During the rotation of the earth in one day, the location of the moon has no much change. Then a place on the earth will pass through two zones in which there are high tides. That is the reason why we see two high tides daily.

Wave Energy : Kinetic energy (movement) exists in the moving waves of the ocean. Waves are a powerful source of energy. That energy can be used to power a turbine. There are several methods of getting energy from waves, but one of the most effective works like a swimming pool wave machine in reverse. At a swimming pool, air is blown in and out of a chamber beside the pool, which makes the water outside bob up and down, causing waves. At a wave power station, the waves arriving cause the water in the chamber to rise and fall, which means that air is forced in and out of the hole in the top of the chamber.

We place a turbine in this hole, which is turned by the air rushing in and out. The turbine turns a generator

Most wave-energy systems are very small. But, they can be used to power a warning buoy or a small light house.

Advantages :

- The energy is free - no fuel needed, no waste produced.
- Not expensive to operate and maintain.
- Can produce a great deal of energy.

Disadvantages :

- Depends on the waves - sometimes you'll get loads of energy, sometimes nothing.
- Needs a suitable site, where waves are consistently strong.
- Some designs are noisy.
- Must be able to withstand very rough weather.

OTHER SIDE OF SEA ENERGY

Tsunami : You may have heard about tsunamis on December 26, 2004 that killed approximately 230,000 people (including 168,000 in Indonesia alone), making it the deadliest tsunami in recorded history.

A tsunami is a series of waves generated when a body of water, such as a lake or ocean is rapidly displaced on a massive scale. Earthquakes, landslides, volcanic eruptions and large meteorite impacts all have the potential to generate a tsunami. The effects of a tsunami can range from unnoticeable to devastating.

The word "tsunami" is Japanese for "harbor wave", because tsunamis cause little or no visible effect in deep sea, and often Japanese fishermen would be out at sea fishing in deep sea when a tsunami came, and in the evening they came home and found their home village devastated by the tsunami, and thus they theorized that tsunamis only happen in harbors and elsewhere close inshore. Tsunamis have been historically referred to as tidal waves because as they approach land they take on the characteristics of a violent onrushing tide rather than the sort of cresting waves that are formed by wind action upon the ocean (with which people are more familiar). However, since they are not actually related to tides the term is considered misleading and its usage discouraged by oceanographers.

A tsunami can be generated by any disturbance that rapidly moves a large mass of water, such as an earthquake, volcanic eruption, landslide or meteorite impact. However, the most common cause is an undersea earthquake. An earthquake which is too small to create a tsunami by itself may trigger an undersea landslide quite capable of generating a tsunami.

Tsunamis can be generated when the sea floor abruptly deforms and vertically displaces the overlying water. Such large vertical movements of the earth's crust can occur at plate boundaries. Subduction earthquakes are particularly effective in generating tsunamis, and occur where denser oceanic plates slip under continental plates in a process known as subduction.

Sub-marine landslides (which are sometimes triggered by large earthquakes) as well as collapses of volcanic edifices may also disturb the overlying water column as sediment and rocks slide downslope and are redistributed across the sea floor. Similarly, a violent submarine volcanic eruption can uplift the water column and form a tsunami. Waves are formed as the displaced water mass moves under the influence of gravity to regain its equilibrium and radiates across the ocean like ripples on a pond.

Often referred to as "tidal waves", a tsunami does not look like the popular impression of "a normal wave only much bigger". Instead it looks rather like an endlessly onrushing tide which forces its way around and through any obstacle. Most of the damage is caused by the huge mass of water behind the initial wave front, as the height of the sea keeps rising fast and floods powerfully into the coastal area. The sheer weight of water is enough to pulverise objects in its path, often reducing buildings to their foundations and scouring exposed ground to the bedrock. Large objects such as ships and boulders can be carried several miles inland before the tsunami subsides.

Tsunamis act very differently from typical surf swells; they are phenomena which move the entire depth of the ocean (often several kilometres deep) rather than just the surface, so they contain immense energy, propagate at high speeds and can travel great trans-oceanic distances with little overall energy loss. A tsunami can cause damage thousands of kilometres from its origin, so there may be several hours between its creation and its impact on a coast, arriving long after the seismic wave generated by the originating event arrives.

A single tsunami event may involve a series of waves of varying heights; the set of waves is called a train. In open water, tsunamis have extremely long periods (the time for the next wave top to pass a point after the previous one), from minutes to hours, and long wavelengths of up to several hundred kilometres. This is very different from typical wind-generated swells on the ocean, which might have a period of about 10 seconds and a wavelength of 150 metres.

The actual height of a tsunami wave in open water is often less than one metre. This is often practically unnoticeable to people on ships. The energy of a tsunami passes through the entire water column to the sea bed, unlike surface waves, which typically reach only down to a depth of 10 m or so.

The wave travels across open ocean at an average speed of 500 mph. As the wave approaches land, the sea shallows and the wave no longer travels as quickly, so it begins to 'pile-up'; the wave-front becomes steeper and taller, and there is less distance between crests. While a person at the surface of deep water would probably not even notice the tsunami, the wave can increase to a height of sixstories or more as it approaches the coastline and compresses. The steepening process is analogous to the cracking of a tapered whip. As a wave goes down the whip from handle to tip, the same energy is deposited in less and less material, which then moves more violently as it receives this energy.

GEOTHERMAL ENERGY

Energy present in the depth of the earth is called geothermal energy. As we move inside the earth from the earth surface the temperature increases with increasing depth. Temperature in the earth at a distance of 10 kilometres is about 120°C and it increases to 300°C at the depth of 320 kilometres. It is evident that temperature increases with depth. Melted liquid, megma is present in the depth of earth. It is surrounded by various layers of soil, sand and water. Whenever there is some passage, it comes in contact with water present between these layers and converts this water into the steam of sufficient pressure. This vapour pressure can be used for production of energy.

There is a huge possibility of the use of this energy in India because here there are 340 hot geological sites. In Manikarn and Kalleshwar the possibilities of the use of geothermal energy are explored. One of the main characteristics of the geothermal energy is that, it is pollution free.

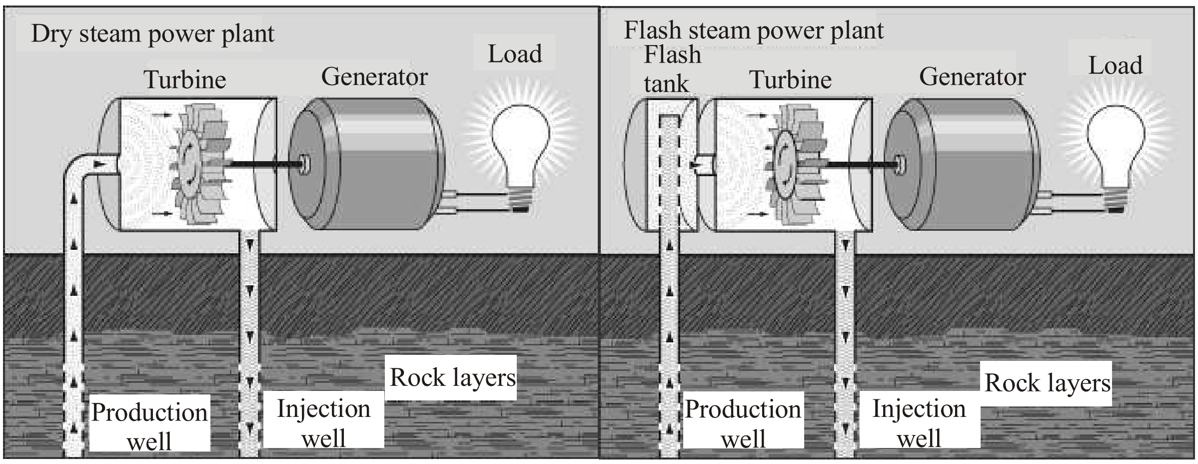
Due to geological changes, molten rocks formed in the deeper hot regions of earth's crust are pushed upward and trapped in certain regions called 'hot spots'. When underground water comes in contact with the hot spot, steam is generated. Sometimes hot water from that region finds outlets at the surface. Such outlets are known as hot springs.

Geothermal springs for power plants. The most common current way of capturing the energy from geothermal sources is to tap into naturally occurring "hydrothermal convection" systems where cooler water seeps into Earth's crust, is heated up, and then rises to the surface.

When heated water is forced to the surface, it is a relatively simple matter to capture that steam and use it to drive electric generators. Geothermal power plants drill their own holes into the rock to more effectively capture the steam.

There are three designs for geothermal power plants, all of which pull hot water and steam from the ground, use it, and then return it as warm water to prolong the life of the heat source. In the simplest design, the steam goes directly through the turbine, then into a condenser where the steam is condensed into water. In a second approach, very hot water is depressurized or "flashed" into steam which can then be used to drive the turbine.

In the third approach, called a binary system, the hot water is passed through a heat exchanger, where it heats a second liquid such as isobutane in a closed loop. The isobutane boils at a lower temperature than water, so it is more easily converted into steam to run the turbine.



The choice of which design to use is determined by the resource. If the water comes out of the well as steam, it can be used directly, as in the first design. If it is hot water of a high enough temperature, a flash system can be used, otherwise it must go through a heat exchanger. Since there are more hot water resources than pure steam or high-temperature water sources, there is more growth potential in the heat exchanger design.
Direct use of geothermal heat. Geothermal springs can also be used directly for heating purposes. Hot spring water is used to heat greenhouses, to dry out fish and de-ice roads, for improving oil recovery, and to heat fish farms and spas.
Hot dry rock. Geothermal heat occurs everywhere under the surface of the earth, but the conditions that make water circulate to the surface are found only in less than 10 percent of Earth's land area. An approach to capturing the heat in dry areas is known as "hot dry rock." The rocks are first broken up by pumping high-pressure water through them. Water is then pumped from the surface down through the broken hot rocks. After the water heats up, it is brought back to the surface through a second well and used to drive turbines for electricity or to provide heat.
The main problem with geothermal, of course, is lack of easily accessible surface sites.
Direct use and heating applications have almost no negative impact on the environment.
Geothermal power plants do not burn fuel to generate electricity, so their emission levels are very low. They release about 1 to 3 percent of the carbon dioxide emissions of a fossil fuel plant. Geothermal plants use scrubber systems to clean the air of hydrogen sulfide that is naturally found in the steam and hot water. Geothermal plants emit 97 percent less acid rain - causing sulfur compounds than are emitted by fossil fuel plants. After the steam and water from a geothermal reservoir have been used, they are injected back into the earth
In other places around the world, people used hot springs for rest and relaxation. The ancient Romans built elaborate buildings to enjoy hot baths, and the Japanese have enjoyed natural hot springs for centuries.

INTERESTING

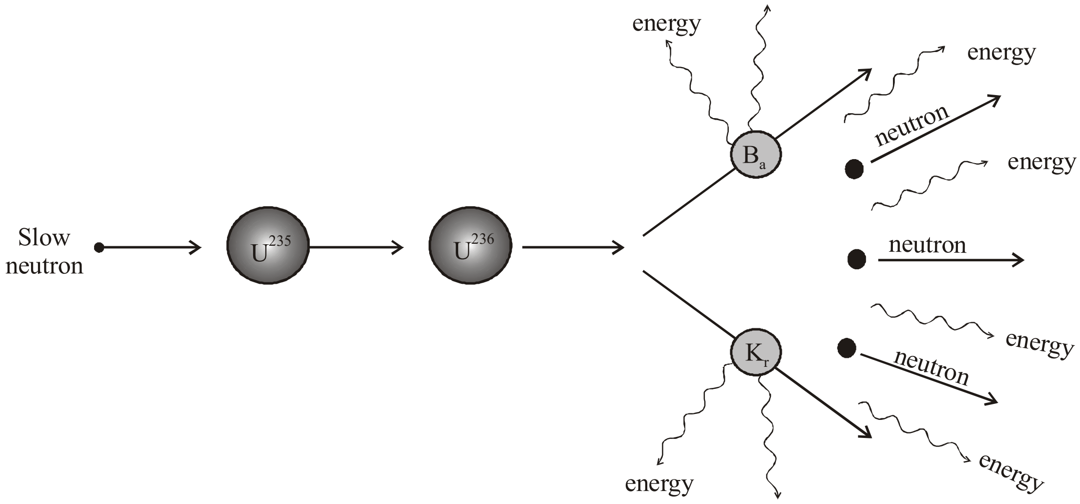
In Iceland, virtually every building in the country is heated with hot spring water. In fact, Iceland gets more than 50 percent of its energy from geothermal sources. In Reykjavik, for example (population 115,000), hot water is piped in from 25 kilometers away, and residents use it for heating and for hot tap water.

NUCLEAR ENERGY

Nuclear power is an alternative energy source that can be obtained from either the splitting of the nuclei of atoms (nuclear fission) or the combining of the nuclei of atoms (nuclear fusion). In either of these two reactions, great amounts of energy are released. Nuclear power plants use a device called a nuclear reactor in which uranium or plutonium atoms are split in controlled fission reactions. The heat energy released is captured and used to generate electricity. Nuclear energy from Uranium is not renewable.
Once we've dug up all the Earth's uranium and used it, there isn't any more.
Nuclear Fission : An atom's nucleus can be split apart. When this is done, a tremendous amount of energy is released. The energy is both heat and light energy. Einstein said that a very small amount of matter contains a very large amount of energy. This energy, when let out slowly, can be harnessed to generate electricity. When it is let out all at once, it can make a tremendous explosion in an atomic bomb. The word fission means to split apart. Inside the reactor of an atomic power plant, uranium atoms are split apart in a controlled chain reaction.

$${}_{92}U^{235} + {}_0n^1 \longrightarrow {}_{92}U^{236} \longrightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + \text{energ}$$

U^{235} nucleus captures a thermal neutron. This forms a compound nucleus U^{236} in excited state
The shape of nucleus is distorted and nucleus splits into two fragments emitting several neutrons.



The energy released in fission of Uranium is about 200 MeV. The fission energy released per nucleon is about 0.84MeV.

In a chain reaction, particles released by the splitting of the atom go off and strike other uranium atoms splitting those. Those particles given off split still other atoms in a chain reaction. In nuclear power plants, control rods are used to keep the splitting regulated so it doesn't go too fast.

If the reaction is not controlled, you could have an atomic bomb. But in atomic bombs, almost pure pieces of the element Uranium-235 or Plutonium, of a precise mass and shape, must be brought together and held together, with great force. These conditions are not present in a nuclear reactor.

The reaction also creates radioactive material. This material could hurt people if released, so it is kept in a solid form. The very strong concrete dome is designed to keep this material inside if an accident happens.

Energy released per gm of Uranium = $\frac{\text{Avogadro number}}{\text{mass number}} \times \text{energy released per fission}$

$$= \frac{6.023 \times 10^{23}}{235} \times 200 = 5.12 \times 10^{23}\,\text{MeV}$$

energy released by 1gm of U^{235} = 5.12×10^{23} MeV = 8.2×10^{10} J = 2.28×10^4 kWh = 2×10^{10} calorie

This energy is equivalent to

(i) energy obtained by burning 2560 kg of coal

(ii) energy obtained by burning 20 tonne of explosive TNT

The energy is released in form of kinetic energy of fission fragments, γ–rays, heat, sound and light energy.

The fission process can take place at normal pressure and temperature.

NUCLEAR FUSION

Another form of nuclear energy is called fusion. Fusion means joining smaller nuclei to make a larger nucleus. The sun uses nuclear fusion of hydrogen atoms into helium atoms. This gives off heat and light and other radiation. Also given off in this fusion reaction is energy.

Scientists have been working on controlling nuclear fusion for a long time, trying to make a fusion reactor to produce electricity. But they have been having trouble learning how to control the reaction in a contained space.

. Controlled nuclear fusion is believed by many scientists to be the ultimate solution to the world's energy problems. The energy released in fusion reactions is many times greater than that released in fission reactions. To date, however, the technology has not been developed to make use of this source of energy. What's better about nuclear fusion is that it creates less radioactive material than fission, and its supply of fuel can last longer than the sun

$$4\,{}_1H^1 \longrightarrow {}_2He^4 + 2\,{}_{+1}e^0 + 2\nu + Q$$

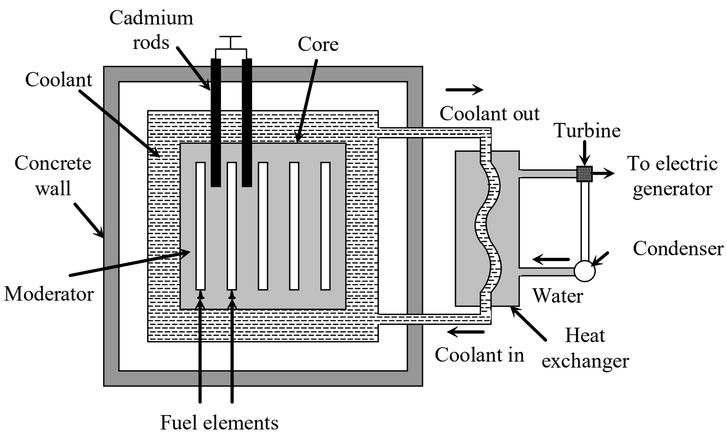
Fusion is possible at high pressure (~ 10^6 atom) and high temperature (~ 10^8 °C)
The proton-proton cycle happens at lower temperature as compared to carbon-nitrogen cycle.
Nuclear fusion in possible at a place which has reactants in large quantity.
Hydrogen bomb works on principle of nuclear fusion.
The explosion of a hydrogen bomb needs an explosion of atom bomb to generate required temperature.
No harmful radiations are produced in fusion.

COMPARISON OF FISSION AND FUSION

Nuclear fission	Nuclear fusion
1. A heavy nucleus splits into two lighter nuclei	Two lighter nuclei join to form a heavy nucleus.
2. Neutrons are required to start fission	Protons are usually required to start fusion.
3. It takes place at normal pressure and temperature.	It takes place at very high pressure and temperature.
4. The energy released per nucleon is small ~ 0.8 MeV	The energy released per nucleon is large ~ 6 MeV.
5. Fissionable material is expensive and not easily available.	Fusion material is cheap and abundantly available.
6. Energy released in fission per cycle is large ~200 MeV	Energy released in fusion per cycle is small ~24.7 MeV.

NUCLEAR REACTORS

A peaceful application of nuclear fission is the generation of electricity using heat from a controlled chain reaction in a nuclear reactor. A nuclear reactor is an arrangement in which the energy produced (in the form of heat) in a nuclear fission can be used in a controlled manner to produce steam, which can run the turbine and produce electricity.



The main part of nuclear reactor :

(a) Nuclear fuel: It is the fissionable material used in nuclear reactors to produce energy by fission process. The nuclear fuel consists of uranium, usually in the form of its oxide, U_3O_8. Naturally occurring uranium contains about 0.7% of uranium 235 isotope which is too low a concentration to sustain a chain reactions. For effective operation of reactor, uranium 235 must be enriched to a concentration of 3 or 4%.

(b) Moderator: An important aspect of the fission process is the speed of the neutrons. Slow neutrons hit uranium-235 nuclei more efficiently than do fast ones. Because fission reactors are highly exothermic, the neutrons produced usually move with high velocities. For greater collision efficiency, neutrons must be slowed down. For this purposes a substance is used that can reduce the kinetic energy of neutrons. Such a substance is called as a moderator. A good moderator should be a nontoxic and inexpensive substance. And it should be resist conversion into radioactive substance by neutron bombardment. Graphite (C) or heavy water (D_2O) are commonly used as moderators.

(c) Control rods: In principle, the main difference between an atomic bomb and nuclear reactor is that the chain reaction that takes place in a nuclear reactor is kept under controlled conditions at all the times. The factor limiting the rate of the reaction is the number of neutrons present. This can be controlled by lowering cadmium or boron rods between the fuel elements.

(d) Coolant: It is the substance which is circulated in pipes to absorb the heat given off by the nuclear reactor and transfer it outside the reactor core, where it is used to produce steam to drive an electric generator. Large quantity of water is used as coolant.

(e) Shield: To prevent the losses of heat and to protect the people operating the reactor from the radiation and heat, the entire reactor core is enclosed in a heavy steel or concrete dome, called the shield.

A complete nuclear power plant essentially consists of the four parts: reactor core, steam generator, steam turbine, and steam condensing system.

Tokamak device :

Device used in nuclear-fusion research for magnetic confinement of plasma. It consists of a complex system of magnetic fields that confine the plasma of reactive charged particles in a hollow, doughnut-shaped container. The tokamak (an acronym from the Russian words for toroidal magnetic confinement) was developed in the mid-1960s by Soviet plasma physicists. It produces the highest plasma temperatures, densities, and confinement durations of any confinement device. It gives hopes for successful making of nuclear fusion reactor.

Uses of nuclear energy :

The important uses of nuclear energy are as follows:

(a) The heat produced in a nuclear reactor is used to boil the water to form steam. The steam then turns a turbine, which runs an electric generator to produce electricity.

(b) Nuclear energy is now being used to run submarines and ships. Vessels driven by nuclear energy can sail for long distances without having to refill.

(c) Nuclear energy in the form of bombs (atom bomb and hydrogen bomb) is used in warfare.

(d) Nuclear energy is used in making radioisotopes that are used in medicine, agriculture and research.

Hazards of producing nuclear energy :

While producing nuclear energy harmful radiations may be released which can penetrate human bodies and cause irreparable damage to cells. To prevent leakage of these dangerous and toxic radiations, nuclear reactors are covered with a thick covering of radiation absorbing substance such as lead. However, a minor fault in the design of reactors or a natural calamity striking a perfectly designed reactor, could result in the release of these extremely harmful radiations into the environment. It could pose a permanent threat to the living beings of the surrounding areas. You may be aware of the two major accidents in the nuclear power plants, one at Three Mile Island (USA) in 1979 and the other at Chernobyl (The Soviet Union) in 1986. The devastation caused in these two accidents by the release of nuclear radiations is yet to be fully assessed. Apart from possible accidents at the reactor site, there is of course, the additional danger of harmful waste matter produced at various steps of nuclear cycle, such as mining, enrichment of ore, etc. In every step of nuclear cycle a number of substance capable of emitting nuclear radiations are generated. These substances are called nuclear wastes. We have not yet been able to discover safe methods of dealing with such nuclear waste generated in nuclear power plants. It is simply being stored in strong containers. Thus, the problem of its disposal is yet to be solved.

Other side of nuclear energy:

Atomic Bomb, powerful explosive nuclear weapon fueled by the splitting, or fission, of the nuclei of specific isotopes of uranium or plutonium in a chain reaction. The strength of the explosion created by an atomic bomb is on the order of the strength of the explosion that would be created by thousands of tons of TNT (Trinitrotoluene).

An atomic bomb must provide enough mass of plutonium or uranium to reach critical mass, the mass at which the nuclear reactions going on inside the material can make up for the neutrons leaving the material through its outside surface. Usually the plutonium or uranium in a bomb is separated into parts so that critical mass is not reached until the bomb is set to explode. At that point, a set of chemical explosives or some other mechanism drives all the different pieces of uranium or plutonium together to produce a critical mass. After this occurs, there are enough neutrons bouncing around in the material to create a chain reaction of fissions. In the fission reactions, collisions between neutrons and uranium or plutonium atoms cause the atoms to split into pairs of nuclear fragments, releasing energy and more neutrons. Once the reactions begin, the neutrons released by each reaction hit other atoms and create more fission reactions until all the fissile material is exhausted or scattered.

This process of fission releases enormous energy in the form of extreme heat and a massive shock wave; this is the intense explosion. In addition to its nearly unimaginable destructive force, consisting of pressure waves, flash burns, and high winds, a nuclear explosion also produces deadly radiation in the form of gamma rays and neutrons. The radiation destroys living matter and contaminates soil and water

Near the end of World War II, on August 6, 1945, the United States dropped the first atomic bomb on the Japanese city of Hiroshima. It followed with a second bomb against the city of Nagasaki on August 9. According to U.S. estimates, 60,000 to 70,000 people were killed by the initial blast of the Hiroshima bomb, called “Little Boy,” and about 40,000 by the bomb dropped on Nagasaki, called “Fat Man.” Japan agreed to Allied terms of surrender on August 14th.

Hydrogen Bomb, also known as H-bomb or thermonuclear bomb, nuclear weapon in which a thermonuclear fusion reaction takes place among heavy isotopes of hydrogen (either deuterium or tritium) to produce an explosion. A hydrogen bomb produces an extremely large explosion, equivalent to millions of tons of TNT (Trinitrotoluene). In the fusion reaction in a hydrogen bomb, two atoms of deuterium or tritium collide to produce a helium atom and extra neutrons. The resulting energy is proportional to the difference in mass between the original atoms and the products of the collision. To ignite this fusion reaction, an environment of tremendous heat is needed, comparable in temperature to heat generated by the Sun.(the temperature raises to 10^7 K in a few microseconds). This condition is created by using a nuclear fission bomb as a trigger. The thermonuclear explosion resulting from the fusion creates great heat, enormous shock waves, high winds, and deadly radiation in the form of gamma rays and neutrons that destroys living matter and contaminates soil and water.

The hydrogen bomb came in part out of the creation of the atomic bomb

The hydrogen bomb is based on thermonuclear fusion reaction. A nuclear bomb based on the fission of uranium or plutonium is placed at the core of the hydrogen bomb. This nuclear bomb is embedded in a substance which contains deuterium and lithium. The high temperature generates sufficient energy for the light nuclei to fuse and a devastating amount of energy is released.

Advantage and disadvantages of various Forms of Alternative Energy:

Solar : Advantages: Always there; no pollution

Disadvantages: Low efficiency (5-15%); Very high initial costs; lack of adequate storage materials (batteries); High cost to the consumer

Hydro:

Advantages: No pollution; Very high efficiency (80%); little waste heat; low cost per KWH; can adjust KWH output to peak loads.

Disadvantages: Fish are endangered species; Sediment buildup and dam failure; changes watershed characteristics; alters hydrological cycle

Wind:

Advantages: none on large scale; supplemental power in windy areas.

Disadvantages: Highly variable source; relatively low efficiency (30%); more power than is needed is produced when the wind blows; efficient energy storage is thus required

Geothermal:

Advantages: very high efficiency; low initial costs since you already got steam

Disadvantages: non-renewable (more is taken out than can be put in by nature); highly local resource

Ocean Thermal Energy Conversion:

Advantages: enormous energy flows; steady flow for decades; can be used on large scale; exploits natural temperature gradients in the ocean

Disadvantages: Enormous engineering effort; Extremely high cost; Damage to coastal environments.

Tidal Energy:

Advantages: Steady source; energy extracted from the potential and kinetic energy of the earth-sun-moon system; can exploit bore tides for maximum efficiency

Disadvantages: low duty cycle due to intermittent tidal flow; huge modification of coastal environment; very high costs for low duty cycle source

Biomass Burning:

Advantages: Biomass waste (wood products, sewage, paper, etc.) are natural by products of our society; reuse as an energy source would be good. Definite co-generation possibilities. Maybe practical for individual landowner.

Disadvantages: Particulate pollution from biomass burners; transport not possible due to moisture content; unclear if growing biomass just for burning use is energy efficient. Large scale facilities are likely impractical.

Nuclear energy:

Advantages :

- Nuclear power costs about the same as coal, so it's not expensive to make.
- Does not produce smoke or carbon dioxide, so it does not contribute to the greenhouse effect.
- Produces huge amounts of energy from small amounts of fuel.
- Produces small amounts of waste.
- Nuclear power is reliable

Disadvantages :

- Although not much waste is produced, it is very, very dangerous.
  It must be sealed up and buried for many years to allow the radioactivity to die away.
- Nuclear power is reliable, but a lot of money has to be spent on safety - if it does go wrong, a nuclear accident can be a major disaster.

TYPES OF NUCLEI

Isotopes : These are nuclei of same element having same Z but different A

e.g. $_8O^{16}, {}_8O^{17}, {}_8O^{18}; {}_1H^1, {}_1H^2, {}_1H^3; {}_{92}U^{234}, {}_{92}U^{235}, {}_{92}U^{238}$

All isotopes of an element have same chemical properties. They occupy same place in periodic table. They cannot be separated by chemical analysis. They can be separated by mass spectrometers or mass spectrographs

Isotones : These are nuclei of different elements having same N but different A.

e.g . $_6C_7^{13}$ & $_7N_7^{14}$; $_1H_2^3$ & $_2He_2^4$; $_2Be_5^9$ & $_5B_5^{10}$

Isotones are different elements with different chemical properties . They occupy different positions in periodic table. They can be separated by chemical analysis and mass spectrometers

Isobars : These are nuclei of different elements having same A but different N and Z.

e.g $_6C^{14}$ and $_7N^{14}$; $_{18}Ar^{40}$ and $_{20}Ca^{40}$

Isobars are different elements with different chemical properties. They occupy different positions in periodic table. They can be separated by chemical analysis but cannot be separated by mass spectrometers

Mirror nuclei : These are nuclei with same A but in which neutron and proton number are interchanged.

e.g. $_4Be_3^7$ (Z = 4, N = 3) and $_3Li_4^7$ (Z = 3, N = 4)

Isomer nuclei : These are nuclei with same A and same Z but differ in their nuclear energy states. They have different life times and internal structure. These nuclei have different radioactive properties. e.g. Co^{60} & Co^{60*}

ATOMIC MASS UNIT

1 atomic mass unit (amu) = $\frac{1}{12}$ of mass of carbon ($_6C^{12}$) atom

$$1 \text{ amu} = \frac{1}{12} \left(\frac{12}{6.023 \times 10^{23}}\right) = 1.66 \times 10^{-24} g = 1.66 \times 10^{-27} \text{ kg}$$

Energy equivalent to 1 amu mass , $E = mc^2 = 1.66 \times 10^{-27} (3 \times 10^8)^2$ joule $= 1.49 \times 10^{-10}$ joule = 931.5 MeV

1 amu = 1.49×10^{-10} J = 931.5 MeV

Mass defect : The mass of the nucleus is always less than the sum of masses of nucleons composing the nucleus. The difference between the rest mass of nucleus and sum of rest masses of nucleons constituting the nucleus is known as mass defect.

Mass defect $\Delta m = [Zm_P + (A - Z)m_n] - M(_ZX^A)$

Binding energy : The energy required to break a nucleus into its constituent nucleons and place them at infinite distance is called binding energy.

The energy equivalent to mass defect is called binding energy. This is the energy with which the nucleons are held together. The binding energies (~MeV) are very large as compared to molecular binding energies (~eV)

Binding energy $BE = (\Delta m) c^2 = c^2 [Zm_P + (A - Z)m_n - M(_ZX^A)]$

rest mass of protons + rest mass of neutrons = rest mass of nucleus + BE

Nuclear reaction : The transformation of one stable nucleus into another nucleus by bombardment with suitable high energy particles like proton, neutron, α particle etc is known as nuclear reaction.

$$_ZX^A + {_2He^4} \longrightarrow {_{Z+2}C^{A+4}} \longrightarrow {_{Z+1}Y^{A+3}} + {_1H^1} + Q$$

Target nucleus	projectile	compound nucleus	product nucleus	energy change

e.g. $_{13}Al^{27} + {_2He^4} \longrightarrow {_{15}P^{31}} \longrightarrow {_{14}Si^{30}} + {_{+1}e^0} + {_0n^1} + Q$

The nuclear reactions obey following conservation laws

(a) conservation of linear momentum **(b)** conservation of total energy **(c)** conservation of charge **(d)** conservation of number of nucleons. **(e)** conservation of angular momentum.

Chain reaction : In fission of Uranium atom 2.5 neutrons are produced on an average. In favourable conditions these may produce fission of other Uranium nuclei. At each stage number of neutrons available for fission gets multiplied which can cause further fission of Uranium nuclei. The process once started continues by itself till entire Uranium is consumed. This process is called nuclear chain reaction.

The neutrons produced in each fission may be lost due to following reasons

(a) Leakage of neutrons from the system **(b)** absorption of neutrons by U^{238}

(c) absorption of neutrons by impurities

Neutron multiplication factor : Neutron multiplication factor $K = \frac{\text{rate of production of neutrons}}{\text{rate of loss of neutrons}}$

(a) If K = 1 chain reaction is sustained.

(i) This leads to a controlled chain reaction. **(ii)** Controlled chain reaction When only one of the neutron produced in each fission is able to produce fission then reaction is called controlled chain reaction.

(iii) The energy is produced at a uniform rate.

(iv) This forms working principle of nuclear reactor.

(v) The size of fissionable material is called critical size and its mass as critical mass.

(vi) The minimum mass of Uranium for which chain reaction is possible is called critical mass. For U^{235} it is 10 kg.

(b) If K > I chain reaction is accelerated because number of neutrons available for fission at each stage increases rapidly

(i) This leads to uncontrolled chain reaction.

(ii) Energy is produced at rapidly increasing rate.

(iii) This is working principle of atom bomb.

(iv) The size of material is super critical.

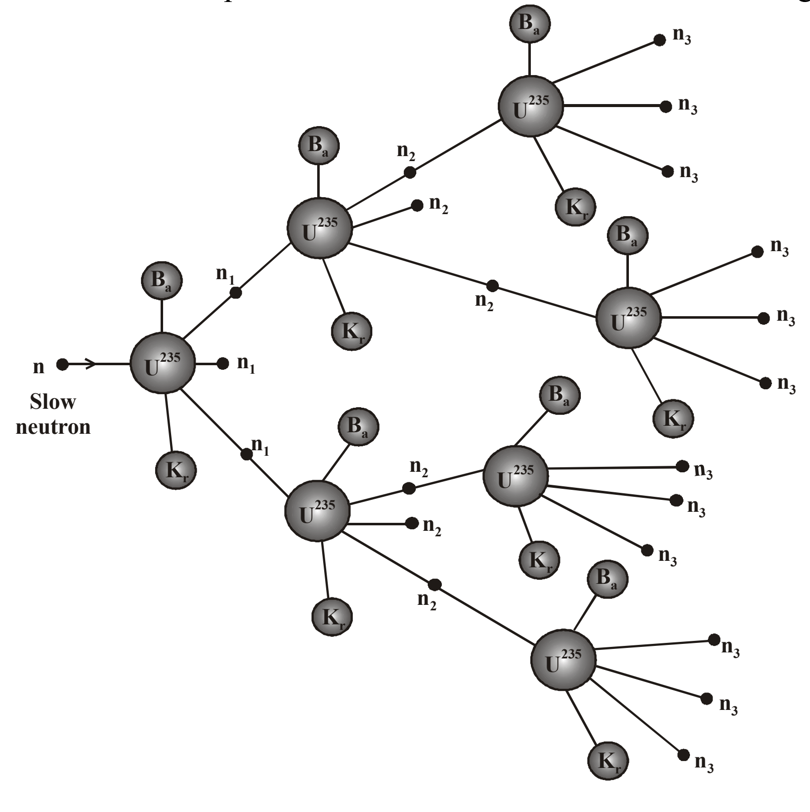
(c) If K < I the chain reaction stops because number of neutrons available for fission decreases at each stage.

(i) The energy produced decreases

(ii) The size of material is sub critical

The rate of decay of neutrons is proportional to surface area (r^2) of Uranium block The rate of production of neutrons is proportional to number of nuclei present in Uranium block or volume (r^3) of the block.

When only one of the neutron produced in each fission is able to produce fission then reaction proceeds slowly and is called controlled chain reaction.



Uncontrolled chain reaction in U^{235}

Breeder Reactor : A reactor which can produce more fissionable fuel than it consumes is called a breeder reactor. No moderator is used in these reactors. Sodium is used as coolant. The chain reaction is maintained by fast neutrons. About 60 to 70% of natural Uranium is used in the process.

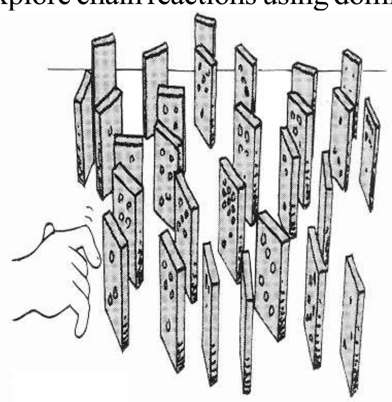
ACTIVITY : Chain reaction

Purpose : To simulate a simple chain reaction.

Required equipment/supplies : 100 dominoes, large table or floor space, stopwatch,

Discussion : You could give your cold to two people; they in turn could give it to two others, each of whom in turn could give it to two others. Before you knew it, everyone in school would be sneezing. You would have set off a chain reaction. Similarly, electrons in a photomultiplier tube in an electronic instrument multiply in a chain reaction so that a tiny input produces a huge output. In this activity, you will explore chain reactions using dominoes.

Procedure :



Step 1: Set up a string of dominoes about half a domino length apart in a straight line, "The Domino Effect." Push the first domino and measure how long it takes for the entire string to fall over. Also notice whether the number of dominoes being knocked over per second increases, decreases, or remains about the same as the pulse runs down the row of dominoes.

Step 2: Set up the dominoes in an arrangement similar to the one in Figure. When one domino falls, another one or two will be knocked over. When you finish setting up all your dominoes, push the first domino over, and time how long it takes for all or most of the dominoes to fall over. Also, notice whether the number of dominoes being knocked over per unit time increases, decreases, or remains about the same.

Analysis :

1. Which approach results in the shorter time to knock over all the dominoes, the one with a line of dominoes or the one with randomly arranged dominoes?
2. How did the number of dominoes being knocked over per unit time change in each procedure?
3. What made each sequence of falling dominoes?
4. Imagine that the dominoes represent the neutrons released by uranium atoms when they fission (split apart). Neutrons from the nucleus of each fissioning uranium atom hit other uranium nuclei and cause them to fission. In a big enough piece of uranium, this chain reaction continues to grow if there are no controls. An atomic explosion would then result in a split second. How is the domino reaction in Step 2 similar to the atomic fission process?
5. How is the domino reaction in Step 2 dissimilar to the atomic fission process?

ENVIRONMENTAL CONSEQUENCES

Exploiting any source of energy disturbs the environment in some way or the other. Wind farms could cause erosion in desert areas. Most often, winds farms affect the natural view because they tend to be located on or just below ridgelines. Bird deaths also occur due to collisions with wind turbines and associated wires. This issue is the subject of on-going research. In any given situation, the source we would choose depends on factors such as the ease of extracting energy from that source, the economics of extracting energy from the source, the efficiency of the technology available and the environmental damage that will be caused by using that source. Though we talk of 'clean' fuels like CNG, it would be more exact to say that a particular source is cleaner than the other. In some cases, the actual operation of a device like the solar cell may be pollution-free, but the assembly of the device would have caused some environmental damage.

Environmental concerns are associated with dams to produce hydroelectric power. People are displaced and prime farmland and forests are lost in the flooded areas above dams. Downstream, dams change the chemical, physical and biological characteristics of the river and land.

Unlike fossil fuels, which dirties the atmosphere, renewable energy has less impact on the environment Renewable energy production has some drawbacks, mainly associated with the use of large of tracts of land that affects animal habitats and outdoor scenery.

Forms of Pollution:

- Atmosphere - Global: Greenhouse gases
- Atmosphere - Local: Smog
- Surface Water - Local: Oil spills
- Atmosphere - Global: Acid Rain
- Groundwater - Local: Nuclear Waste
- Thermal Pollution - Local and Global: Waste Heat

Air Pollution:

Normally the carbon content of fuels (which is high) oxidizes during the combustion process to form CO_2 (carbon dioxide)

Incomplete combustion leads to the formation of CO: $2C + O_2 \rightarrow 2CO$

Sources of CO pollution: (million tons per year)

Motor Vehicles $\rightarrow$ 54, Aircraft $\rightarrow$ 2, Coal $\rightarrow$ 0.7, Fuel Oil $\rightarrow$ 0.1, Industrial Wood Processing $\rightarrow$ 8.8, Forest Fires $\rightarrow$ 6.5

Automobiles dominate because the combustion of gasoline under conditions of high pressure is quite incomplete.

ACTIVITY :

- Gather information about various energy sources and how each one affects the environment.
- Debate the merits and demerits of each source and select the best source of energy on this basis.

How long will an energy source last us ?

85% of the energy used in the world today is produced using non-renewable energy sources. This percentage is forecast to remain the same through 2030 unless something changes drastically such as the widespread enactment of legislation, breakthroughs in energy technology or the development of abundant, inexpensive new energy sources. We will never run out of fossil fuels, but at some point, the cost of recovering a fuel, say a barrel of oil, will exceed the profits to be made from selling that barrel of oil. At that point we will lose that fuel as an energy source. The big question is "How soon will this happen?" Surely we cannot depend on the fossil fuels for much longer.

Such sources that will get depleted some day are said to be exhaustible sources or non-renewable sources of energy. On the other hand, if we manage bio-mass by replacing the trees we cut down for fire-wood, we can be assured of a constant supply of energy at a particular rate. Such energy sources that can be regenerated are called renewable sources of energy.

Renewable energy is available in our natural environment, in the form of some continuing or repetitive currents of energy, or is stored in such large underground reservoirs that the rate of depletion of the reservoir because of extraction of usable energy is practically negligible.

ACTIVITY

- Debate the following two issues in class.
  (a) The estimated coal reserves are said to be enough to last us for another two hundred years. Do you think we need to worry about coal getting depleted in this case? Why or why not?
  (b) It is estimated that the Sun will last for another five billion years. Do we have to worry about solar energy getting exhausted? Why or why not?
- On the basis of the debate, decide which energy sources can be considered (i) exhaustible, (ii) inexhaustible, (iii) renewable and (iv) non-renewable. Give your reasons for each choice.

ADDITIONAL EXAMPLES

Example 1 :

Compare and contrast fossil fuels and the Sun as direct sources of energy.

Sol. (i) The reserves of fossil fuels are limited, i.e., exhaustible whereas solar energy is available in abundance (and that too without cost), i.e., is inexhaustible.

(ii) Fossils fuels cause pollution on burning whereas solar energy is pollution free.

(iii) Fossil fuels can provide energy at any required time whereas solar energy becomes unavailable when the sky is covered with clouds.

Example 2 :

If 200 MeV energy is released per fission of U^{235} nuclei. Find the mass of U^{235} consumed per day in a reactor of power 1MW assuming its efficiency as 80%.

Sol. Energy produced in one day = $10^6 \times 24 \times 60 \times 60$ joule

$$\eta = 0.8 = \frac{\text{output energy}}{\text{input energy}} = \frac{10^6 \times 24 \times 60 \times 60}{\text{input energy}}. \text{ So input energy} = \frac{10^6 \times 24 \times 60 \times 60}{0.8} = 10.8 \times 10^{10}\ \text{J}$$

energy released in one fission = $200 \times 10^6 \times 1.6 \times 10^{-19} = 3.2 \times 10^{-11}$ J

$$\text{no. of fissions per day} = \frac{10.8 \times 10^{10}}{3.2 \times 10^{-11}} = 3.375 \times 10^{21}$$

mass of U^{235} required = no. of nuclei disintegrating per day × mass of U^{235}

$= 3.375 \times 10^{21} \times 235 \times 1.67 \times 10^{-27} = 1.324$ mg

Example 3 :

If you could use any source of energy for heating your food, which one would you use and why?

Sol. Gas stove or Microwave oven since they will do my job without pollution in a shorter time.

Example 4 :

What are the disadvantages of fossil fuels?

Sol. (i) The fossil fuels are non-renewable sources of energy. If we were to continue consuming these sources at such alarming rates, we would soon run out of energy.

(ii) Air pollution is caused by burning fossil fuels.

(iii) The oxides of carbon, nitrogen and sulphur that are released on burning fossil fuels are acidic oxides. These lead to acid rain which affects out water and soil resources.

Example 5 :

Why are we looking at alternate sources of energy?

Sol. We are looking at alternate sources of energy because

(i) the fossil fuel reserves in the earth are limited which may get exhausted soon if continued to be used at current rate.

(ii) the use of alternate sources of energy will reduce pressure on fossil fuels making them last for a much longer time.

(iii) the pollution being caused by the burning of fossil fuels can be avoided by using alternate sources of energy.

Example 6 :

How has the traditional use of wind and water energy been modified for our convenience?

Sol. The traditional use of wind has been modified by using windmills and that of water by constructing hydroelectric power plants.

Example 7 :

What kind of mirror – concave, convex or plain – would be best suited for use in a solar cooker? Why?

Sol. A concave mirror would be first suited for use in a solar cooker. When a concave mirror reflector is attached to a solar cooker, it converges a large amount of sun's heat rays at its focus due to which a high temperature is produced in the focus area.

Example 8 :

What are the limitations of the energy that can be obtained from the oceans?

Sol. The limitations of the energy that can be obtained from the oceans (tidal energy, wave energy and ocean thermal energy).(i) Need very sensitive devices. (ii) Lesser conversion efficiency and frequent maintenance.

Example 9 :

What is geothermal energy?

Sol. The energy extracted from hot water springs on the earth is called geothermal energy.

Example 10 :

What are the advantages of nuclear energy?

Sol. (i) It produces a huge amount of energy from a very small amount of nuclear fuel.

(ii) It does not produce gases like carbon dioxide which contribute to greenhouse effect or sulphur dioxide which causes acid rain. (iii) Once the nuclear fuel is loaded into the reactor, the nuclear power plant can go on producing electricity for two to three years at a stretch. Hence, there is no need for putting in nuclear fuel again and again.

Example 11 :

Can any source of energy be pollution-free? Why or why not?

Sol. No any source of energy be pollution free. Exploiting any source of energy disturbs the environment in some way or the other. Only the degree and manner of pollution varies. In some cases, the actual operation of a device like the solar cell may be pollution-free, but the assembly of the device would have caused some environmental damage.

Example 12 :

Hydrogen has been used as a rocket fuel. Would you consider it a cleaner fuel than CNG? Why or why not?

Sol. Hydrogen is a cleaner fuel than CNG because the burning of hydrogen produces only water, which is completely harmless. The burning of CNG produces carbon dioxide and water. This CO_2 can produce greenhouse effect in the atmosphere and lead to the excessive heating of the environment in the long run.

Example 13 :

Name two energy sources that you would consider to be renewable. Give reasons for your choices.

Sol. (i) wind energy (ii) solar energy

These sources of energy can be used again and again endlessly. They will never get exhausted.

Example 14 :

Give the names of two energy sources that you would consider to be exhaustible. Give reasons for your choices.

Sol. (i) Fossil fuels (ii) Nuclear fuels

Fossil fuels are present in a limited amount in the earth. Once exhausted, they will not be available to us again. The nuclear material which can be conveniently extracted from the earth are limited and hence they will get exhausted one day.

Example 15 :

What is a good source of energy?

Sol. Good source of energy has following characters :

(i) Capable of providing adequate amount of energy.

(ii) Should be covenient to use and easy to store and transport.

(iii) Should be capable of giving desired quantity at required rate steadily over, a long period.

(iv) Should release energy in mostly all forms in which the day-to-day requirement exists.

Example 16 :

Compare and contrast bio-mass and hydro electricity as sources of energy.

Sol. (i) Bio-mass is a renewable source of energy only if we plant trees in a planned manner which is not the case with hydroelectricity. (ii) The energy from bio-mass can be obtained by using a chulhas or a gobar gas plant whereas hydroelectricity requires construction of dams on rivers. (iii) Bio-mass provides pollution-free energy only when converted into biogas whereas hydroelectricity is totally pollution-free.

Example 17 :

What are the limitations of extracting energy from – (a) the wind? (b) waves? (c) tides

Sol. (a) (i) Not available at all time and at all places. (ii) Needs large open field.

(b) (i) Affected by wind movement. (ii) Not available at all places.

(c) (i) Depends on the phase of moon. (ii) Conversion efficiency is less

Example 18 :

On what basis would you classify energy sources as (a) renewable and non-renewable?

(b) exhaustible and inexhaustible?

Are the options given in (a) and (b) the same?

Sol. We would classify energy sources as (a) renewable and non-renewable.

Renewable sources of energy are inexhaustible whereas non-renewable sources of energy are exhaustible.

Thus, the options in (a) and (b) are the same.

Example 19 :

What are the qualities of an ideal source of energy ?

Sol. (i) An ideal fuel is that which gives us more heat per unit mass.

(ii) An ideal fuel is that which does not pollute air on burning by giving out smoke or harmful gases.

(iii) It should be cheap and easily available.

(iv) It should be easy to handle, safe to transport.

Example 20 :

What are the advantages and disadvantages of using a solar cooker? Are there places where solar cookers would have limited utility ?

Sol. Advantages of Solar Cooker :

(i) It saves fuel. (ii) It does not create pollution. (iii) The nutrients of food do not get destroyed.

Limitations of Solar Cooker : (i) It cannot be used during night time. (ii) It cannot be used on cloudy day.

(iii) The direction of reflector of solar cooker has to be adjusted frequently.

(iv) It cannot be used for frying. (v) It cannot be used for making chapaties. (vi) It takes longer time for cooking.

Example 21 :

What are the environmental consequences of the increasing demand for energy ?

What steps would you suggest to reduce energy consumption?

Sol. (i) More pollution levels. (ii) Quicker depletion of conventional sources.

Overcoming Energy Crisis. Energy crisis can be overcome by : (i) Judicious use of the available energy (ii) Promoting renewable energy sources (iii) Promoting efficient conversion mechanism and (iv) Accelerate the pace of development of technologies required for harnessing new sources.

Example 22 :

Determine the number of electrons, protons and neutrons in 8g of ${}_6C^{12}$.

Sol. Each atom of ${}_6C^{12}$ of has 6n, 6p, 6e , no. of atoms in 8gm = $\dfrac{6.023\times10^{23}}{12}\times 8 = 4.015\times10^{23}$ atoms.

number of neutron, proton and electron $= 6\times4.015\times10^{23} = 24\times10^{23}$

Example 23 :

Determine the ratio of radius of nuclei ${}_{13}Al^{27}$ and ${}_{52}Te^{125}$

Sol. As $R \propto A^{1/3}$ So, $\dfrac{R_{Al}}{R_{Te}} = \left(\dfrac{A_{Al}}{A_{Te}}\right)^{1/3} = \left(\dfrac{27}{125}\right)^{1/3} = \left(\dfrac{3^3}{5^3}\right)^{1/3} = \dfrac{3}{5}$

Example 24 :

A nucleus breaks into two parts whose velocity is in ratio 2:1 . Find the ratio of their radius.

Sol. As per conservation of momentum $m_1v_1 + m_2v_2 = 0$

So $\dfrac{m_1}{m_2} = \dfrac{v_2}{v_1}$; ratio of radii $\dfrac{R_1}{R_2} = \left(\dfrac{A_1}{A_2}\right)^{1/3} = \left(\dfrac{m_1}{m_2}\right)^{1/3} = \left(\dfrac{1}{2}\right)^{1/3}$ so $R_1 : R_2 = 1 : 2^{1/3}$

Example 25 :

Calculate the mass defect of a deutron (${}_1H^2$). Given M(${}_1H^2$) = 2.014102 amu,

m_n = 1.008665 amu, m_p = 1.007825 amu .

Sol. mass defect $\Delta m = [Zm_p + (A-Z)m_n] - M({}_1H^2) = (1\times1.007825 + (2-1)1.008665) - 2.014102 = 0.002388$amu

CONCEPT MAP

SOURCES OF ENERGY

* **Characteristics of a source of Energy**

- Convenient to use and
- Easy to transport and store.
- Capable of delivering desired quantity of energy at a steady rate over a long period of time.
- Easily accessible

* **Law of conservation of energy** "the energy can neither be created nor be destroyed but can be convert from one form to other."

* **Fossil fuel**: fuels which are obtained from the remains of plants and animals are called fossil fuels. Ex- coal and petroleum. Fossil fuels are **non-renewable sources of energy** so we need to conserve them.

* **Harmful effects of fossil fuels**

The acidic oxides of carbon, nitrogen and sulphur are released on burning fossils fuels. These lead to **acid rain** which affects our water and soil resources. Air pollution and production of green house gases like carbon dioxide.

* **Thermal power plant**

In thermal power plant fuel is burnt to produce heat energy which is converted into electrical energy for generating electricity. The simple turbines have one moving part, a rotor-blade assembly. The moving fluid acts on the blades to spin them and impact energy to the rotor. As the fan move, the rotor blade, with speed turn the shaft of the dynamo and convert the mechanical energy into electrical energy.

* **Hydro power plant**

High-rise dams are constructed to collect water in large artificial lakes by obstructing the flow of a river. In the process, the kinetic energy of water gets transformed into potential energy. The water from the top of the dam is made to fall through pipes over the turbine blades at the bottom of the dam. Moving turbine rotates the armature of the electric generators to produce electricity. Other advantages of constructing dams on rivers are that it helps in irrigation and in controlling floods.

* **Biomass as Fuel :** The material contained in the bodies of plant and animals is called biomass.

Ex-excreta of living beings, waste from tree, grass, crop etc.

* **Biogas :** Biogas plants a fixed dome type and a floating gas holder type. Cow dung is used to obtain biogas. The fixed dome type biogas plants have the advantage that the dome can be constructed by laying bricks. Fixed dome has a longer life. Cow dung and water is made in the mixing tank from where it is fed into the digester. The digester is usually a closed underground tank made by laying bricks. In digester the action of microorganisms breaks down or decomposes the complex compounds of the biomass in the slurry. Biogas may contain up to 75%methane. It is an excellent fuel and burns without producing smoke.

Uses of biogas-as a fuel for domestic purpose -

- Used as fuel to run engines
- Used as illuminant
- Slurry left as a residue is a good source of manure

Composition of biogas

$CH_4 = 65 – 75\%$, $CO_2 = 20 - 30\%$,
$H_2 = 5 – 10\%$, $H_2S = 2\%$

* **Bio Energy:-** A small fraction of the solar energy radiation on the earth's surface is converted into chemical energy by green plants. Biomass has been a traditional source of heat. For example, wood, crop residues, baggage (residue of sugarcane) are burnt to

CONCEPT MAP

SOURCES OF ENERGY

produce heat for domestic, as well as industrial purposes. Biomass is also utilized to produce electricity.

* **Wind energy:-** Moving air is called wind. It posses kinetic energy. Modern windmills are designed to convert wind energy into mechanical or electrical energy.
A windmill construction similar to a large electric fan that is erected at some height. The blades of a windmill are designed to create a pressure difference between its different regions when wind strikes them. This pressure difference produces a turning effect to make the blades rotate. The speed of rotation may increase or decrease depending on the wind velocity.

Solar Energy: Energy we get from sun is called solar energy.
The solar Energy received per square meter per second on the surface of earth is called solar constant .it's value is approximately equal to 1.4 kW/m^2

* **Solar Cookers and Water Heaters**
The plain glass is transparent to light, that is it allows light to pass through it. It is also transparent to infrared radiation whose wavelengths are close to the visible light. When the box with glass cover is placed in the sun, visible as well as infrared radiation pass through the glass into the box. Most of these are absorbed by the black surface of its inner walls. They too begin to radiate heat in the form of infra-red radiation. Much longer than the incoming, infrared. The Property of glass is that it allows infrared radiation of shorter wavelengths.
The Solar Cooker is made from non-conducting materials like plastics or fiberglass, with its inner walls painted in black. The walls of the box are made thick with a lining of non-conducting material to prevent loss of heat. A plane mirror is hinged on the top of the box. The mirror reflects sunlight into the box. The main purpose of the mirror is to increase the effective area for the collection of solar energy. The box is covered with a glass sheet that facilitates retention of heat and cooks the food.

* **Solar cell-** The devices that convert solar energy directly into electricity are known as **solar cells**. **Silicon** is used to manufacture solar cells. Silicon has the advantage that it is environmental friendly and is also available in abundance. Solar cells have been designed that consist of a number of thin layers of silicon. These multiplayer silicon solar cells have been found to convert energy from both the visible as well as the infrared radiation into electricity. When a large number of solar cells are used together is known as **solar panel**. Solar cells provide a clean, pollution free and environment friendly source of electricity.
Solar cell is used for Wireless transmissions, TV relay stations, Traffic lights, Research centers located in remote areas, Calculators, Toys fitted etc.

* **Energy from Water** (sea)
Tidal energy:- Oceans are huge reservoirs of water and energy. The oceans store energy in many forms. The energy possessed by the rising and falling water in tides is known as **tidal energy**. A dam is constructed across a narrow opening to the sea. The water moves in and out of the opening in the dam during high and low tides (Due to gravitational pull by moon). As the water moves through the openings, it flows over the turbines fixed inside the dam that generate electricity.

* **Sea Wave energy:-** The kinetic energy possessed by huge waves near the seashore can be trapped to generate electricity. The waves are generated by strong wind blow

CONCEPT MAP

SOURCES OF ENERGY

ing across the sea.

* **Ocean energy systems:-**. The difference in temperature between warm surface waters and colder waters found at ocean depths are another form in which solar energy becomes available from the oceans. This known **as ocean thermal energy**. The devices used to utilize this form of ocean energy are known as Ocean thermal energy conversion (OTEC) power plants. A temperature difference of 20°C or more between surface waters and water at depths up to 1000 meter is required for operating OTEC systems. In one of the OTEC system, the warm surface water is used to boil a liquid like ammonia or a chlorofluorocarbon (CFC). The vapour of the liquid is then used to drive turbine of generator. The cold water from the ocean depths is pumped up to convert the vapour again into liquid and convert it into electric energy.

* **Geo thermal energy:-** The energy of hot water below the earth is called geothermal energy.
  Due to geological changes, molten rocks formed in the deeper hot regions of earth's crust are pushed upward and trapped in certain regions called **hot spots**. When underground water comes in contact with the hot spot, steam is generated. Some times hot water from that region finds outlets at the surface. Such outlets are known as hot springs or geysers.

* **Nuclear reactions:-** A reaction in which atomic nucleus undergoes a change is called a nuclear reaction. Radioactive decay is spontaneous nuclear reaction. When a fast moving alpha particle (helium nucleus) collides with a nitrogen nucleus, an oxygen nucleus is formed and a proton is emitted.

Nuclear Fusion:- The process in which two or more light nuclei fuse together to form a heavy nucleus along with the release of energy is called nuclear fusion.ex -sun

$$_1H^1 + {}_1H^1 + {}_1H^1 + {}_1H^1 \rightarrow {}_2He^4 + \text{energy } (4.6 \times 10^{-12}\text{ J})$$

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{59}Ba + ^{92}_{36}Cr + 3^{1}_{0}n + O$$

Nuclear Fission:- The process of a heavy nucleus splitting into two middleweight nuclei is called nuclear fission U.
Ex. - Nuclear Bombs

* **Environmental Consequences :**
  Exploiting any source of energy disturbs the environment in some way or the other. The source chosen must depends on factors such as the case of extracting energy from that source, the economics of extracting energy from the source, the efficiency of the technology available and the environmental damage that will be caused by using that source. Though we talk of 'clean' fuels like CNG, it would be more exact to say that a particular source is cleaner than the other. Burning fossil cause's air pollution. The actual operation of a device like the solar cell may be pollution-free.

* **How long will an energy source last ……**
  We must use the resources judiciously and carefully.
  Promotional action for the usage of renewable sources of energy like rain water harvesting, use of solar panels, growing more trees.
  We should follow the steps to use the resources forever ….

QUESTION BANK

EXERCISE - 1

Q.1 Does wind possess kinetic for potential energy ?

Q.2 What is a turbine ?

Q.3 Name the device which converts solar energy directly into electricity.

Q.4 What do you mean by hydro energy ?

Q.5 What do you mean by tidal energy ?

Q.6 Why it is not possible to use the energy which is consumed?

Q.7 What energy transformation takes place when we light a candle and drop a metal plate from a certain height?

Q.8 What are fossil fuels?

Q.9 What was the most common source of heat energy in ancient times?

Q.10 Which fuel meets the growing demand of energy nowadays and the past?

Q.11 What made us to look for alternative source of energy?

Q.12 What are main disadvantages of using fossil fuels and how can we minimize it?

Q.13 What causes acid rain?

Q.14 What energy transformation is done by a dynamo?

Q.15 List out the different power plants from which we get electrical energy?

Q.16 Why most of the thermal power plants are set near coal or oil mines?

Q.17 Why hydro power plants are associated with dams?

Q.18 Give the reason for the coining of the word thermal power plant?

Q.19 Give few example for how our ancestors used the energy possessed by the wind and water.

Q.20 Write the working of a hydro power plant with a neat diagram?

Q.21 What are the advantages and disadvantages of using energy from water?

Q.22 What is bio- mass and write few examples of bio mass?

Q.23 How is charcoal formed and what are the advantages of using charcoal as a source of energy?

Q.24 What is the composition of bio-gas and the matter rich in the slurry left behind in the bio-gas plant?

Q.25 What is the major disadvantage of bio-mass and how can it be overcome ?

Q.26 How do nuclear energy and wind energy differ from each other and also write a similarity between them.

Q.27 What do you mean by backup facility and where do you require it?

Q.28 There is nuclear reactor of power 300MW and a wind mill farm constructed in an area of 10 hectares. Calculate for how long the windmill farm should work continuously to give energy equal to the energy produced by the reactor if the reactor doesn't function for one day?

Q.29 In a day time a nuclear reactor produces 3600×10^6J of energy. Calculate the time taken by a wind energy farm of area 4 hectares to produce that much of energy?

Q.30 What is the major source of energy for the sun?

Q.31 What substance functions as the fuel for the sun?

Q.32 For how long time our Sun will tend to supply energy from it?

Q.33 Define solar constant and give its value on the upper atmosphere and on the lower atmosphere?

Q.34 Draw the schematic picture a solar cooker?

Q.35 How do you classify the solar energy devices ? and explain.

Q.36 What energy transformation takes place in the solar cooker?

Q.37 Write the different parts of a box type solar cooker.

Q.38 Explain the working of a solar cooker.
Q.39 What is the role of a glass sheet and black coated surface of a box type solar cooker?
Q.40 Which type of solar spectrum is trapped in the solar cooker?
Q.41 To achieve higher temperature what is done in some solar cookers?
Q.42 What is a solar cell?
Q.43 What are the advantages and disadvantages of a solar cell?
Q.44 What energy transformation takes place in a solar cell?
Q.45 What factors make a solar cell very expensive?
Q.46 What are the uses of solar cells?
Q.47 What is a solar panel ?
Q.48 What is the cause for the tides on the ocean? (or) how are tides formed?
Q.49 How do you harness tidal energy?
Q.50 How wave energy is an indirect form of solar energy?

EXERCISE - 2

FILL IN THE BLANKS :

Q.1 Many of the sources ultimately derive their energy from the............
Q.2 Solar constant = ...
Q.3 A device that utilises solar energy for cooking purposes is called a ....
Q.4 A solar cell is a device which converts solar energy directly into ....
Q.5 The energy possesses by wind is called ....
Q.6 The flowing water possesses .... energy
Q.7 Oceans covers about .... of the earth's surface and are the .... source of water on the earth. Because of the large mass of water in oceans and high .... of water, oceans at as store house of ....
Q.8 Electricity generated from sea waves is ....
Q.9 The internal heat of an earth is known as .... energy.
Q.10 .... is the remaining part of the sugarcane from which juice has been extracted.
Q.11 Bio-gas is a mixture of ...., carbon dioxide, ... and ....
Q.12 When a complex material is heated strongly in the absence of air, then it decomposes to the simplest substance. This process is called ....
Q.13 The material obtained from the bodies of plants and animals is called ....
Q.14 The decomposition, which takes place in the absence of oxygen by anaerobic bacteria, is called ....
Q.15 Type of radiation emitted by a hot electric iron ....

TRUE-FALSE STATEMENTS –

Q.16 Our energy requirements increase with our standard of living.
Q.17 In order to fulfil our energy requirements, we try to improve the efficiency of energy usage and also try and exploit new sources of energy.
Q.18 The main constituent of biogas is not methane.
Q.19 Black colour is a very good absorber of heat and good reflector.
Q.20 The use of geothermal energy cause pollution.
Q.21 Deep drilling in the earth to obtain geothermal energy is very difficult.
Q.22 Charcoal is a better fuel than wood and coal.

Q.23 Bio-gas is a better fuel than animal dung-cakes.
Q.24 The sun-rays fall on the equatorial region more intensively than any other part of the earth.
Q.25 The calorific value of methane is less than that of butane.

EXERCISE - 3

Q.1 Most of the energy we use originally came from –
(A) the sun (B) the air (C) the soil (D) the oceans

Q.2 Electrical energy can be produced from –
(A) mechanical energy (B) chemical energy (C) radiant energy (D) All of the above

Q.3 Coal, petroleum, natural gas, and propane are fossil fuels. They are called fossil fuels because:
(A) they are burned to release energy and they cause air pollution
(B) they were formed from the buried remains of plants and tiny animals that lived hundred of millions of years ago
(C) they are nonrenewable and will run out (D) they are mixed with fossils to provide energy

Q.4 Gasoline is produced by refining which fossil fuel?
(A) natural gas (B) coal (C) petroleum (D) propane

Q.5 Propane is used instead of natural gas on many farms and in rural areas. Why is propane often used instead of natural gas?
(A) it's safer (B) it's portable (C) it's cleaner (D) it's cheaper

Q.6 What sector of the Indian economy consumes most of the nation's petroleum?
(A) residential (B) commercial (C) industrial (D) transportation

Q.7 Natural gas is transported mainly by
(A) pipelines (B) trucks (C) barges (D) all three equally

Q.8 Global warming focuses on an increase in the level of which gas in the atmosphere?
(A) ozone (B) sulfur dioxide (C) carbon dioxide (D) nitrous oxide

Q.9 Solar, biomass, geothermal, wind, and hydropower energy are all renewable sources of energy. They are called renewable because they –
(A) are clean and free to use (B) can be converted directly into heat and electricity
(C) can be replenished by nature in a short period of time
(D) do not produce air pollution

Q.10 Today, which renewable energy source provides the India with the most energy?
(A) wind (B) solar (C) geothermal (D) hydropower

Q.11 How much of the energy in burning coal reaches the consumer as electricity –
(A) 1/3 (one-third) (B) 1/2 (one-half) (C) 3/4 (three-quarters) (D) 9/10 (nine-tenths)

Q.12 In a nuclear power plant, uranium atoms
(A) combine and give off heat energy (B) split and give off heat energy
(C) burn and give off heat energy (D) split and give off electrons

Q.13 Solar energy is produced by the following reaction–
(A) Fission reaction (B) Fusion reaction (C) Chemical reaction (D) None of the above

Q.14 Which form of energy is contained in wind energy –
(A) Kinetic energy (B) Potential energy (C) Electric energy (D) Thermal energy

Q.15 In biogas, which gas is present in maximum amount–
(A) Carbon dioxide (B) Methane (C) Hydrogen (D) Oxygen

Q.16 Which one of the following is not a source of non-convential energy –
(A) Coal (B) Solar energy (C) Wind energy (D) Biogas

Q.17 White energy is freely available in ample amount of–
(A) Sunlight (B) Water gas (C) Hydrogen (D) Wind energy

Q.18 Gobar gas is –
(A) foul smelling gas (B) sweet smelling gas (C) having high caloric value (D) useless

Q.19 Biogas is produced from biomatter by –
(A) anaerobic fermentation (B) distructing distillation
(C) fractional distillation (D) mixing petrol in biomatter

Q.20 L.P.G. is mostly liquified –
(A) hydrogen (B) oxygen (C) butane (D) methane

Q.21 The volume occupied by an atom is greater then the volume of the nucleus by a factor of about –
(A) 10^1 (B) 10^5 (C) 10^{10} (D) 10^{15}

Q.22 Which of the following is true for isotopes of specimen of U^{235} and U^{238}
(A) both contain same number of neutrons
(B) both contain same of number of proton, electron and neutron
(C) both contain same number of proton and electron but U^{238} contains three more neutrons than U^{235}
(D) U^{238} contain three less neutrons than U^{235}

Q.23 Atomic nucleus contains
(A) electron & photon (B) electron, proton & neutron
(C) electron & neutron (D) proton & neutron

Q.24 The atomic number & mass number of element is Z & m then number of neutron will be -
(A) m x z (B) m + z (C) m / z (D) m – z

Q.25 Nuclei containing different number of protons but same number of neutrons are called -
(A) Iso clinics (B) isobars (C) isotones (D) isotopes

Q.26 1 amu is equivalent to -
(A) 9.31 MeV (B) 931 KeV (C) 93.1 MeV (D) 931 MeV

Q.27 The dependence of density [d] of nuclear matter on the mass number A is -
(A) $d \propto A$ (B) $d \propto \sqrt{A}$ (C) d = const. (D) $d \propto 1/A$

Q.28 The wrong statement is -
(A) Nuclear forces are strongest (B) Nuclear forces are very short range forces
(C) Nuclear force increase when the number of nucleons is increased
(D) Nuclear force is produced by the exchange of pions

Q.29 Range of nuclear force is approximately -
(A) 2×10^{-10} m (B) 1.5×10^{-20} m (C) 7.2×10^{-4} m (D) 1.4×10^{-15} m

Q.30 The mass number of a nucleus is equal to the number of -
(A) Electron it contains (B) Protons it contains (C) Neutrons it contains (D) Nucleons it contains

Q.31 The neutron was discovered by
(A) Marie Curie (B) Pierre Curie (C) James Chadwick (D) Rutherford

Q.32 The order of magnitude of the density of nuclear matter is-
(A) 10^4 kg/m^3 (B) 10^{17} kg/m^3 (C) 10^{27} kg/m^3 (D) 10^{34} kg/m^3

Q.33 Force between protons in nucleus will be -
(A) only nuclear (B) only coulomb (C) nuclear & coulomb (D) coulomb & gravitational

Q.34 The mass equivalent of 931 MeV energy is
(A) 1.66×10^{-27} kg (B) 6.02×10^{-24} kg (C) 1.66×10^{-20} kg (D) 6.02×10^{-27} kg

Q.35 Boron rods are used in nuclear reactor as -
(A) moderator (B) control rods (C) coolant (D) protective shield

Q.36 Best moderator for neutron is -
(A) berillium oxide (B) pure water (C) heavy water (D) graphite

Q.37 Nuclear fission was discovered by
(A) OttoHahn and strassman (B) Fermi (C) Bethe (D) Rutherford

Q.38 The rest mass energy of an electron is -
(A) 510 kilo eV (B) 931 kilo eV (C) 510 MeV (D) 931 MeV

Q.39 The Process by which a heavy nucleus splits into light nuclei is known as -
(A) Fission (B) α-decay (C) Fusion (D) Chain reaction

Q.40 200 MeV of energy may be obtained per fission of U^{235}. A reactor is generating 1000 kW of power. The rate of nuclear fission in the reactor is -
(A) 1000 (B) 2×10^{8} (C) 3.125×10^{16} (D) 931

Q.41 In the process of nuclear fusion -
(A) Only heavy nucleus break into light nuclei
(B) Fusion of light nuclei at normal temperature
(C) Fusion of light nuclei at high pressure and low temperature
(D) Fusion of light nuclei at high pressure and high temperature

Q.42 When ${}_{92}U^{235}$ undergoes fission 0.1% of its original mass is changed into energy. How much energy is released if 1kg of ${}_{92}U^{235}$ undergoes fission -
(A) 9×10^{10} J (B) 9×10^{11} J (C) 9×10^{12} J (D) 9×10^{13} J

Q.43 In nuclear power station energy of uranium is used for producing -
(A) Electrical energy (B) Mechanical energy (C) Heat energy (D) Magnetic energy

Q.44 Sun and stars get their radiation energy by -
(A) Fission process (B) Fusion process
(C) Disintegration process (D) Photo-electric effect

Q.45 The cause of energy liberated in nuclear reaction is -
(A) Change of potential energy into kinetic energy
(B) Kinetic energy of resultant nucleus
(C) Energy equivalent to mass lost (D) None of these

Q.46 Atom bomb consists of pieces of ${}_{92}U^{235}$ and a source of -
(A) Proton (B) Neutron (C) Meson (D) Electron

Q.47 When four hydrogen nuclei fuse together to form helium nucleus, then in this process-
(A) Energy is absorbed. (B) Energy is liberated.
(C) Absorption and liberation of energy depends upon the temperature.
(D) Energy is neither liberated nor absorbed.

Q.48 Two lighter nuclei are fused together to form a nucleus of medium atomic mass and energy is released in this process because-
(A) Binding energy of lighter nuclei is more. (B) Binding energy per nucleon of lighter nuclei is more.
(C) Binding energy per nucleon of medium nucleus is more.
(D) Energy is always released when two nuclei are fused.

Q.49 Neutron ratio (available/used per fission in atomic reactor and atom bomb are-
(A) $r > 1$ in atomic reactor and $r < 1$ in bomb. (B) $r = 1$ in atomic reactor and $r > 1$ in bomb.
(C) $r > 1$ in both atomic reactor and bomb. (D) $r < 1$ in both atomic reactor and bomb.

Q.50 The nuclear fuel in the sun is –
(A) helium (B) uranium (C) alpha particles (D) hydrogen

Q.51 In atomic explosion, a temperature of about 10 million degrees is developed at the moment of explosion. The wavelength of light coming from the hot region of the atomic explosion lie in the region-
(A) ultraviolet region (B) visible region (C) infrared region (D) x-ray region

Q.52 In nuclear fission process energy releases because–
(A) Mass of particles is more than mass of nucleus
(B) binding energy of products formed due to nuclear fission is more than parent fissionable material
(C) binding energy of products formed due to nuclear fission is less than parent fissionable material
(D) mass of some particles converts in to energy

Q.53 For nuclear fusion reaction–
(A) Heavy nucleus are required (B) Light nucleus are required
(C) Both type (D) None of these

Q.54 Fission of nuclei is possible because the binding energy per nucleon in them–
(A) increases with mass number at low mass numbers
(B) decreases with mass number at low mass number
(C) increases with mass number at high mass numbers
(D) decreases with mass number at high mass number

Q.55 A solar water heater cannot be used to get hot water on
(A) a sunny day (B) a cloudy day (C) a hot day (D) a windy day

Q.56 Which of the following is not an example of a bio-mass energy source –
(A) wood (B) gobar-gas (C) nuclear energy (D) coal

Q.57 Most of the sources of energy we use represent stored solar energy. Which of the following is not ultimately derived from the Sun's energy?
(A) geothermal energy (B) wind energy (C) nuclear energy (D) bio-mass.

Q.58 When light is incident on surface, photo electrons are emitted. For photoelectrons-
(A) The value of kinetic energy is same
(B) Kinetic energy does not depend on the wave length of incident light
(C) The value of kinetic energy is equal to or less than a maximum energy
(D) None of the above

Q.59 The phenomenon of photo electric emission depends on-
(A) Only wave length of incident light (B) Only work function of surface
(C) Only nature of surface (D) All of the above

Q.60 Photo electric effect is the phenomenon in which-
(A) Photons come out of a metal when it is hit by a beam of electrons
(B) Photons come out of the nucleus of an atom under the action of an electric filed
(C) Electrons come out of metal with a constant velocity depending on frequency and intensity of incident light
(D) Electrons come out of a metal with different velocity not greater than a certain value which depends only on the frequency of the incident light wave and not on its intensity.

EXERCISE - 4

MATCH THE COLUMN–

Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **column I** have to be matched with statements (p, q, r, s) in **column II**.

Q.1 Match the processes given in Column I with the nuclear reactions given in Column II. Symbol Q stands for energy released.

Column I	Column II
(A) Alpha decay	(p) ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\left({}^{1}_{0}n\right) + Q$
(B) Beta decay	(q) ${}^{3}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}He + Q$
(C) Nuclear fission	(r) ${}^{230}_{90}Th \rightarrow {}^{226}_{90}Ra + {}^{4}_{2}He + Q$
(D) Nuclear fusion	(s) ${}^{137}_{55}Cs \rightarrow {}^{137}_{56}Ba + e^{-} + \overline{v} + Q$

Q.2 Column II give fission probability relative to U^{236} for nuclide given in column I match them correctly.

Column I	Column II
(A) U^{236}	(p) 0.001
(B) U^{239}	(q) 1
(C) Pu^{240}	(r) 1.5
(D) Am^{244}	(s) 0.0002

Q.3 Match the processes in column I with their properties in Column II.

Column I	Column II
(A) Nuclear fission	(p) involves weak nuclear forces
(B) Nuclear fusion	(q) involves conversion of matter into energy
(C) β-decay	(r) atoms of higher atomic number are used
(D) Exothermic nuclear	(s) atoms of lower atomic reaction number are used

Q.4 Match the following columns

Column I	Column II
(A) Nuclear fusion	(p) Converts some matter into energy
(B) Nuclear fission	(q) Generally possible for nuclei with low atomic no.
(C) β-decay	(r) Generally possible for nuclei with higher atomic number
(D) Exothermic nuclear	(s) Essentially proceeds by reaction weak nuclear forces

ASSERTION & REASON TYPE

Each question contains STATEMENT-1 (Assertion) and STATEMENT-2 (Reason). Each question has 5 choices (A), (B), (C), (D) and (E) out of which ONLY ONE is correct.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement -1 is True, Statement-2 is False.
(D) Statement -1 is False, Statement-2 is True.
(E) Statement -1 is False, Statement-2 is False.

Q.5 **Statement 1 :** Nuclear forces are independent of charges.
Statement 2 : Nuclear force is not a central force.

Q.6 **Statement 1 :** The strength of photoelectric current depends upon the intensity of incident radiation.
Statement 2 : A photon of energy E (= hν) possesses a mass equal to E/c^2 and momentum equal to E/c.

Q.7 **Statement 1 :** Binding energy (or mass defect) of hydrogen nucleus is zero.
Statement 2 : Hydrogen nucleus contain only one nucleon.

Q.8 **Statement 1 :** U^{235} nucleus, by absorbing a slow neutron undergoes nuclear fission with the evolution of a significant quantity of heat
Statement 2 : During nuclear fission a part of the original mass of U^{235} is lost and gets converted into heat.

Q.9 **Statement 1 :** The rest mass energy of a nucleus is smaller than the rest mass energy of its constituent nucleons in free state.
Statement 2 : Nucleons are bound together in a nucleus.

Q.10 **Statement 1 :** In a decay process of a nucleus, the mass of products is less than that of the parent.
Statement 2 : The rest mass energy of the products must be less than that of the parents.

Q.11 **Statement 1 :** In street light circuits, photo-cells are used to switch on and off the lights automatically at dusk and dawn.
Statement 2 : A photocell can convert a change in intensity of illumination into a change in photocurrent that can be used to control lighting system.

EXERCISE - 5

PREVIOUS YEARS BOARD QUESTIONS

Q.1 Name the process of large energy production in the sun.
Q.2 Why CNG considered as environmental friendly fuel ?
Q.3 Name two main combustible components of biogas.
Q.4 Name any two elements that are used in fabricating solar cells.
Q.5 A decoration light has red, blue, green and yellow bulbs in series, which one of them would give off light of longest and shortest wavelength ?
Q.6 Which two components of sunlight are not visible to us ?
Q.7 How sunlight is converted to heat in a box type solar cooker?
Q.8 Name any one element that is used in making solar cells. On what property of the element in this use based ?
Q.9 Name the major constituent of natural gas.
Q.10 State the energy transformation taking place when a boy is ridding a bicycle.
Q.11 What is power ? Write its S.I. unit.
Q.12 What is the order of electric current produced by a solar cell measuring 4 cm^2 ?
Q.13 Which component of sunlight facilitates drying of wheat during harvesting ?
Q.14 Write any two harmful radiations emitted by nuclear wastes.
Q.15 Name any two radiations emitted by the sun that are not visible to human eye.
Q.16 Name the component of sunlight prolonged exposure to which may cause skin cancer.
Q.17 Mention any two harmful effects of nuclear radiations on human body.
Q.18 Name any two semiconductors which are used in manufacture of solar cells.
Q.19 Name the main constituents of gas.
Q.20 In what respect fuel oil is better than coal ?
Q.21 How many joules of energy is needed to raise the temperature of one kilogram of water through 1°C ?

Q.22 A torch cell converts one form of energy to another form. Name these forms.
Q.23 In which form would you like to convert cow dung to maximum advantage ?
Q.24 Name the device which directly convert solar energy to electrical energy.
Q.25 Lights from two different sources A and B have wavelength 0.3 micron and 0.7 micron respectively. Which one of the two light carry more energy per photon ?
Q.26 State the composition of water gas.
Q.27 The mass number of three elements A, B and C are 2, 180 and 230 respectively. Which one of them is suitable to make a hydrogen bomb ?
Q.28 What is the range of temperature which can be attained in a box type solar cooker in two to three hours exposure to sun.
Q.29 Mention any two uses of wind energy.
Q.30 Name the type of nuclear reaction by which the Sun produces its energy. List two conditions which are present at the centre of the Sun responsible for this reaction.
Q.31 What is the cause of release of unusually large energies in nuclear fission reactions ? How is the energy per fission calculated?
Q.32 Define a ‘nuclear fusion reaction’. Describe the conditions for the occurrence of a nuclear fusion reaction.
Q.33 Give one example of a nuclear fusion reaction. Describe one method for making such reaction possible.
Q.34 The sue of dry wood as domestic fuel is not considered as good. State two reasons for it.
Q.35 Why burning of firewood in traditional chulhas is considered disadvantageous ? (Give two reasons)
Q.36 In which forms the solar energy stored in the oceans ? Mention any two forms that could be harnessed to obtain energy in usable form.
Q.37 Electricity generated at hydroelectric power stations is considered to be another form of solar energy. Explain.
Q.38 People at hill stations often get sunburns on their skin. Which component of sunlight is responsible for this ? Why is this effect not usually observed near sea level ?
Q.39 How is biogas produced ? Which component of biogas is useful as a fuel ?
Q.40 Name two fuels which are produced from water. Give their composition.

ANSWER KEY

EXERCISE - 1

(1) Kinetic energy **(3)** Solar cell.

EXERCISE - 2

(1) Sun **(2)** 1.4 kW/m^2 **(3)** solar cooker. **(4)** electricity. **(5)** wind energy
(6) kinetic **(7)** 70.8%, biggest, heat capacity, energy **(8)** tidal energy **(9)** geothermal
(10) Bagasse **(11)** methane, hydrogen, hydrogen sulphide **(12)** destructive distillation.
(13) biomass **(14)** anaerobic degradation **(15)** Infrared radiations.
(16) True **(17)** True **(18)** False **(19)** False **(20)** False
(21) True **(22)** True **(23)** True **(24)** True **(25)** False

EXERCISE - 3

Q	1	2	3	4	5	6	7	8	9	10	11
A	A	D	B	C	B	D	A	C	C	D	A
Q	12	13	14	15	16	17	18	19	20	21	22
A	B	B	A	B	A	A	C	A	C	C	C
Q	23	24	25	26	27	28	29	30	31	32	33
A	D	D	C	D	C	C	D	D	C	B	C
Q	34	35	36	37	38	39	40	41	42	43	44
A	A	B	C	A	A	A	C	D	A	A	B
Q	45	46	47	48	49	50	51	52	53	54	55
A	C	B	B	C	B	D	D	B	C	D	B
Q	56	57	58	59	60						
A	C	C	C	D	C						

EXERCISE - 4

(1) (A) → r (B) → s (C) → p (D) → q **(2)** (A) → q (B) → p (C) → r (D) → s
(3) (A) → q, r (B) → q, s (C) → p (D) → q **(4)** (A) → p, q (B) → p, r (C) → s, p (D) → p, q, r
(5) (B) **(6)** (B) **(7)** (A) **(8)** (A)
(9) (A) **(10)** (A) **(11)** (A)

EXERCISE - 5

(1) Nuclear fusion reaction. **(2)** CNG gas create less pollution.
(3) (i) Methane (ii) Hydrogen. **(4)** Silicon and Germanium.
(5) Longest Wavelength – Red ; Shortest Wavelength – Blue.
(6) Infra-red and Ultra-violet. **(8)** Germanium or Silicon.
(12) 0.4 to 0.5 volt at 6.0 mA. **(13)** Infra-red radiation.
(14) α, β and γ rays. (Any two) **(15)** Infra-red and Ultra-violet.
(16) Ultra-violet light. **(17)** (i) Genetical disorders (ii) Skin cancer.
(18) Silicon and Germanium. **(21)** 4180 joules.
(23) Biogas. **(24)** Solar cell. **(28)** 100ºC to 140ºC.
(29) (i) To produce electricity. (ii) To lift water or grind materials.