5. Towards Green Energy

- **Use of various energy sources**
- **Generation of electrical energy**
- **Process of generation of electricity and environment**

Can you recall?

1. What is Energy?
2. What are different types of Energy?
3. What are different forms of Energy?

Let's Discuss

Make a list of the work that we do in our day to day life using energy. Which forms of energy do we use to do this work? Discuss with your friends.

Energy and use of energy

In modern civilization, energy has become a primary need along with food, cloth and shelter. We need energy in different forms for diverse types of works. The energy that we need may be in the form of mechanical energy, chemical energy,sound energy, light energy or heat energy. How do we get these different forms of energy?

Make a table Make a table based on forms of energy and corresponding devices.

We know that energy can be converted from one form to another. Different sources of energy are used to the different forms of energy necessory for us. In previous standards we have learnt about energy, sources of energy and various concepts related to them. Here we will learn about various sources that are now used for the generation of elecrical energy, the methods that are used for this, the scientific principles that are used there, the advantages and disadvantages of these methods and also what is meant by green energy.

Can you tell?

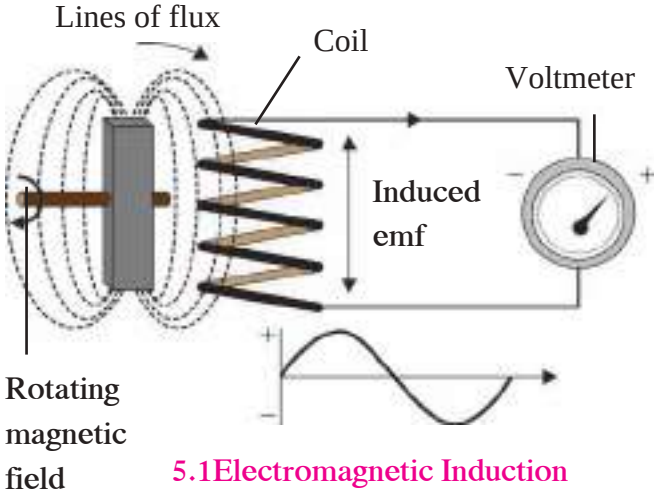
1. Where do we use electrical energy in our day-to-day life?
2. How Electric energy is produced ?

Generation of electrical energy

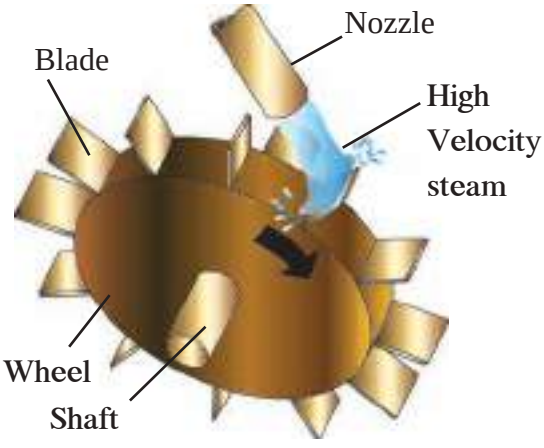
Most of the electric power plants are based on the principle of electromagnetic induction invented by Michael Faraday. According to this principle, whenever magnetic field around a conductor changes, a potential difference is generated across the conductor.

The field around a conductor can be changed in two ways. If a conductor is stationary and magnet is rotating, the field around the conductor changes or if a magnet is stationary, but the conductor is moving then also the field around the conductor will change. Thus, in both these cases, a potential difference is created across the conductor. (Figure 5.1). The electrical power generating machine based on this principle is called electric generator.

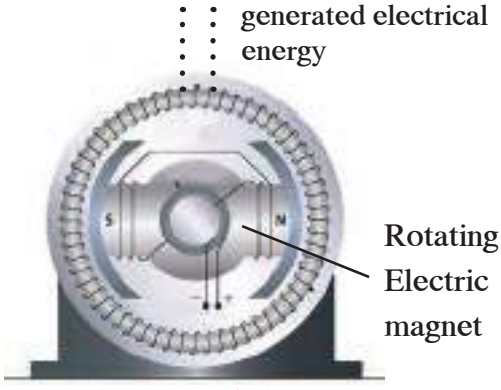
Such large generators are used in commercial power generation plants. Turbine is used to rotate the magnet in the generator. A turbine has blades .When a flow of liquid or gas is directed on the blades of the turbine, it rotates (see Figure 5.2). because of the kinetic energy of the flow.This turbine is connected to electric generator. Thus the magnet in electric generator starts rotating and electric energy is produced (Fig.5.3)



5.1Electromagnetic Induction



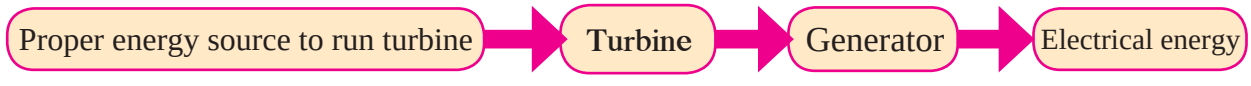
5.2 Steam turbine



5.3 Schematic of electric generator

This method of electric energy generation can be represented as below.

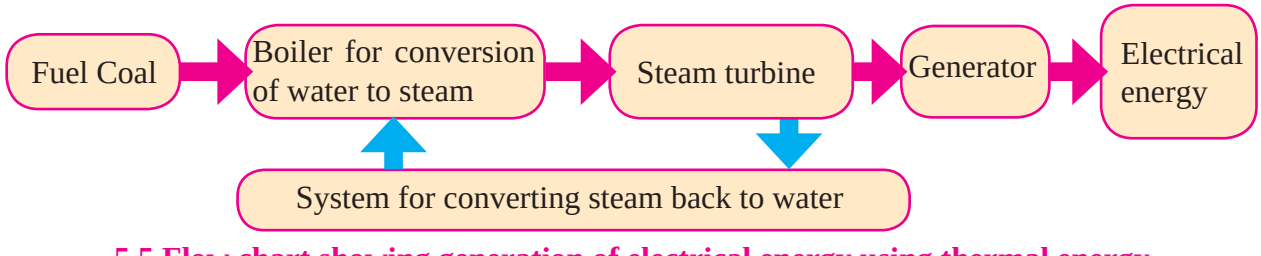
Thus, to generate electricity based on the principle of electromagnetic induction, we need a generator. To rotate the generator we need a turbine and to drive the turbine, we need an energy source. Based on which type of energy source is used to rotate the turbine, there are different types of power generating stations. The design of the turbine used in different types of power stations is also different.



5.4 Flow chart showing generation of electrical energy

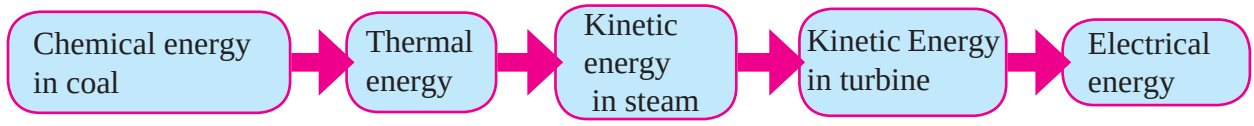
Thermal energy based electric power station

In this the turbine is rotated using steam. Water is heated in a boiler. Using the thermal energy released due to burning of coal. Steam of very high temperature and pressure is generated. The energy in the steam drives the turbine. Thus, the generator connected to the turbine rotates and electrical energy is produced. The steam is converted back into water and the water is re-circulated to the boiler.This is shown in flow chart in fig 5.5



5.5 Flow chart showing generation of electrical energy using thermal energy

Since thermal energy is used here to generate electrical energy, such power plants are called thermal power plants. In thermal power plants, the chemical energy in the coal is converted into electrical energy through several steps which are shown in figure 5.6.



5.6 Energy transformation in thermal power plant

Lets Think

1. Why the energy in the coal is called as chemical energy?
2. Why steam is used to rotate the turbine?

5.7 Schematics of Thermal : power plant

If you see a thermal power station, you will observe two types of towers there. What are they? If you observe the schematic of the thermal power station in Figure 5.7 , you will get answer to this question.

Compare the schematic of the thermal power station with the block diagram above and you will understand how the boiler, turbine, generator and the condenser are arranged in the power station.

After combustion of fuel (here, coal) in the boiler, the emitted gases are released to the atmosphere through very high tower. Once the turbine is rotated using the steam at high temperature and high pressure, steam temperature and pressure decreases. This steam is converted back to water by taking out heat from it (i.e by cooling it) . This is done in the condenser using water in the cooling tower. The water in cooling tower is circulated through the condenser. Heat energy in the steam is given to the water and the steam condenses back to water. The heat absorbed by the water is then released to atmosphere through vapour and heated air through cooling tower. Although, thermal power generation is a major way of electricity generation today, it suffers from certain problems

Use of ICT

Prepare a presentation about thermal power plant using computerized presentation, animation, video pictures etc. Send it to others and upload on You Tube

Problems

1. Air pollution due to burning of coal: Burning of coal results in emission of gases like carbon dioxide, sulphur oxide and nitrogen oxide which are harmful to the health.
2. Along with the emission of gases due to burning of coal, soot particles are also released into the environment. This may cause serious health problems related to the respiratory system.

Do you know?

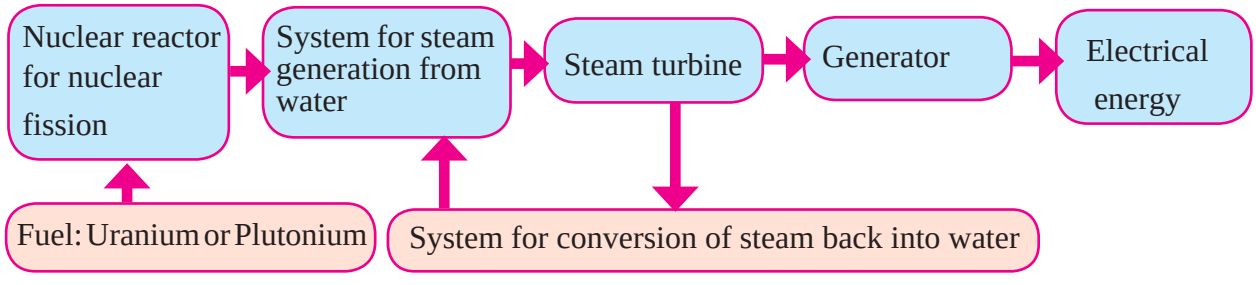
Some major thermal power plants in India and their capacity

Place	State	Capacity (MW)
Vindhyanagar	Madhya Pradesh	4760
Mundra	Gujarath	4,620
Mundra	Gujarath	4,000
Tamnaar	Chhattisagarh	3,400
Chandrapur	Maharashtra	3,340

3. The reserves of fuel used in this method i.e. coal are limited. Therefore, in future, there will be limitations on the availability of the coal .

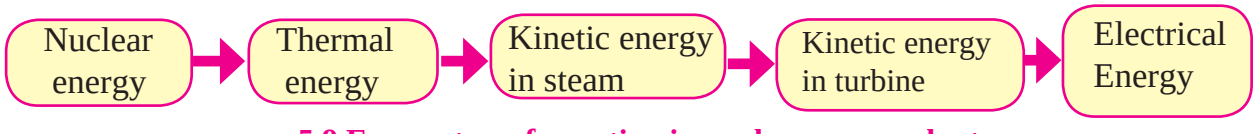
Power plant based on Nuclear Energy

In the power plant based on nuclear energy also , steam turbine is used to rotate the generator. However, here, the energy released by fission of nuclei of atoms like Uranium or Plutonium is used to generate the steam of high temperature and high pressure. The energy in the steam rotates the turbine, which in turn drives the generator producing electricity. The flow chart of nuclear power plant is shown in fig 5.8 .



5.8 Nuclear power plant

Thus, here nuclear energy is converted into thermal energy, thermal energy is converted into kinetic energy of steam, kinetic energy of steam is converted into kinetic energy of turbine and finally the kinetic energy of the turbine is converted into electrical energy .The step-by-step transformation of energy is shown in figure 5.5.



5.9 Energy transformation in nuclear power plant

Can you tell? How does nuclear fission take place?

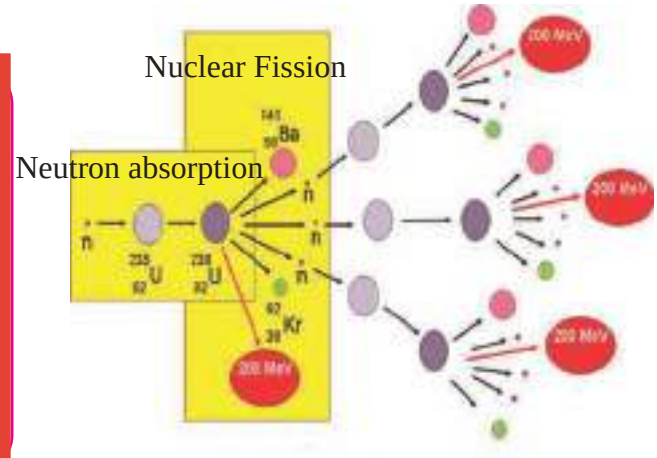
When neutron is bombarded on atom of Uranium - 235 , it absorbs the neutron and converts into its isotope Uranium - 236. Uranium - 236 being extremely unstable converts into atoms of Barium and Krypton through a process of fission releasing three neutrons and 200 MeV energy. The three neutrons generated in this process cause fission of three other Uranium - 235 atoms releasing more energy.

The neutrons released in this reactionrelease more energy through fission of more uranium nuclei. This process of fission of U ranium -235 atoms continnues and is called the chain reaction. In nuclear power plants, a controlled chain reaction results in release of thermal energy, which is used for electric energy generation.

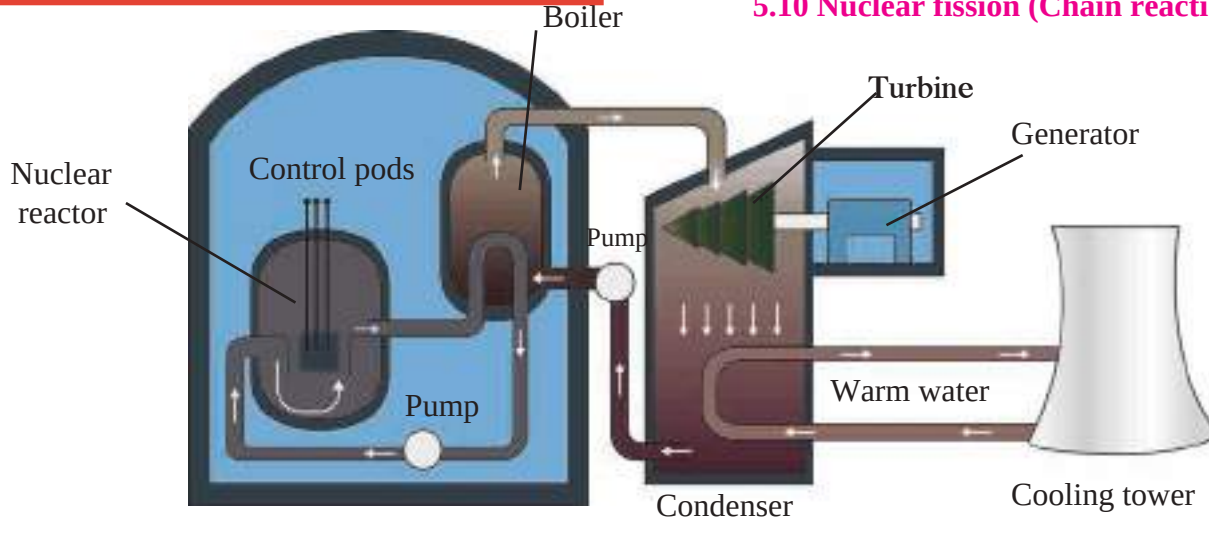
Internet is my friend

Complete the following table for some important nuclear power plants in india.

Place	State	Capacity (MW)
Kudankulam	.....	.....
Tarapur	.....	.....
Ravatabhata	.....	.....
kaiga	.....	.....



5.10 Nuclear fission (Chain reaction)



5.11 Schematic of nuclear power plant

A nuclear power plant does not use fossil fuel like coal. Therefore, problems like air pollution do not arise. Also, if sufficient nuclear fuel is available, this can be a good source of electrical energy. However, there are few problems associated with nuclear power generation.

Problems:

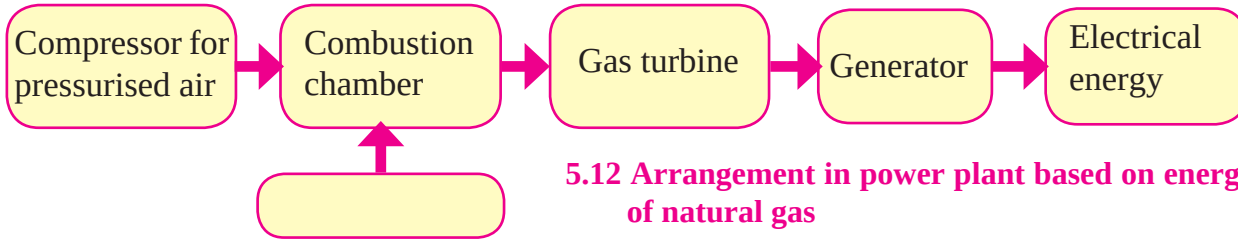
1. The products after fission of nuclear fuel are also radioactive and emit harmful radiations. The products are called as nuclear waste. How to dispose the nuclear waste safely is a big challenge before the scientists.
2. An accident in nuclear power plant can be very fatal. This is because the accident may result in release of very harmful radiations.

Compare

Observe the schematic of thermal power plant and the nuclear power plant. Discuss what are the similarities and differences between the two?

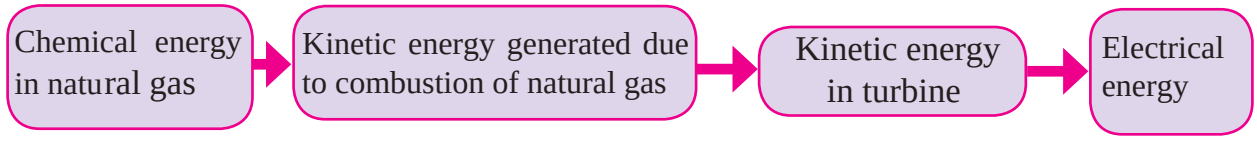
Power generation plant based on energy of natural gas

In this plant, the turbine is run by a gas at very high temperature and pressure generated by combustion of natural gas. A flow chart showing various stages in the power generation plant based on natural gas energy is shown in figure 5.12.



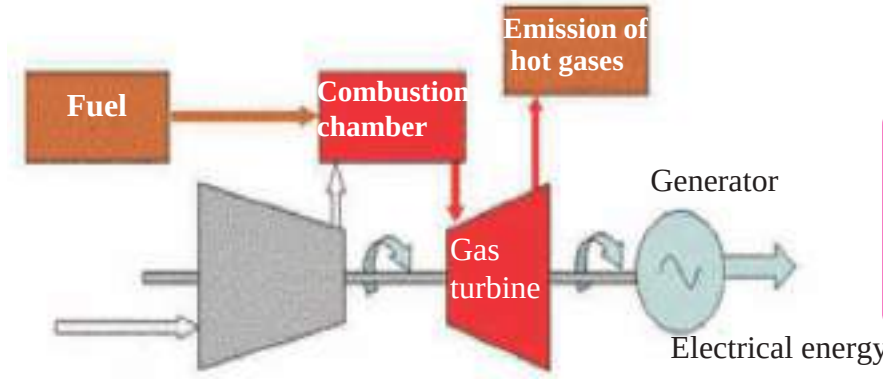
5.12 Arrangement in power plant based on energy of natural gas

There are three main sections in this type of plant. Pressurised air is introduced into the combustion chamber using a compressor. In the combustion chamber the natural gas burns in presence of the air. The gas at very high temperature and pressure generated in this chamber runs the turbine. The turbine then drives the generator to produce electricity. Step-by-step transformation of energy in this plant is shown in fig 5.13.



5.13 Transformation of energy in power plant using energy of natural gas

The efficiency of this type of power generation plant is higher than that of power generation plant based on coal. Moreover, since the natural gas does not contain sulphur, burning of natural gas results in less pollution. The schematic of power plant based on natural gas is given in fiure 5.14.



5.14 Schematic of power plant based on natural gas

Lets Think

Which electricity generation process is ecofriendly and which not?

Some natural gas based power plants and their capacity

Place	State	Capacity(MW)
Samaralkota	Andhra Pradesh	2620
Anjanvel	Maharashtra	2,220
Bavanaa	Delhi	1,500
Kondapalli	Andhra Pradesh	1466

Always remember

Though use of energy is unavoidable in our day to day life, it is necessary to use it carefully and only in the required amount.

Electric energy generation and environment

Electricity generation based on fossil fuels like coal, natural gas and nuclear fuels like uranium and plutonium are not environment friendly. It means, that if electrical energy is generated using these fuels, it can lead to environmental degradation.

1. We have seen that burning of fossil fuels like coal, and natural gas leads to emission of certain gases and soot particles. This results in air pollution. Incomplete combustion of fuels leads to formation of carbon monoxide. It adversly affects our health. Increase in percentage of carbon dioxide in the air due to burning of fuels affects environment severely. The phenomena of global warming is an example of this. Nitrogen dioxide generated due to burning of fuels like coal, diesel, petrol, etc. lead to problems like acid-rain. Soot particles generated due to incomplete burning of fossil fuel cause air pollution. It can lead to problems related to respiratory system, like asthama.
2. It took millions of years for formation of fossil fuels like coal, crude oils and natural gases (LPG and CNG). Also, the reserves of these fuels are limited. They are going to deplete in future. It is said that with the current speed of their use, the coal reserves in the world would last for another about 200 years or so and the natural gas reserves for about 200-300 years.
3. We have also discussed above about the problems in use of nuclear energy like the disposal of nuclear waste and possibility of disaster due to accident in nuclear power plant.

Considering all these points, it can be said that the energy generation from fossil fuels and nuclear fuels are not environment friendly.

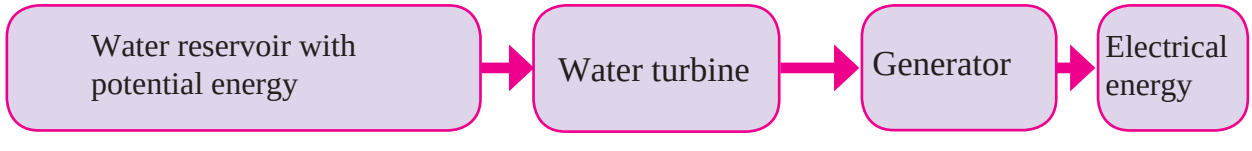
Towards environment friendly energy…..towards green energy:

There are other ways of electricity production which avoids above problems. Electricity generation from water reservoir, wind, Sunlight, biofuels etc are the examples of such methods. The energy sources used in such options i.e. water--reservoir, wind, sunlight, biofuel are never-ending i.e are perpetual. Moreover, use of these sources do not lead to environmental problems discusses above. Therefore, electricity generation through these sources can be called environment friendly. We can also call the energy generated by these processes as green energy. Looking at the problems in electricity generation using fuels like coal, natural gas and nuclear fuels, the world is now heading towards environment friendly energy i.e. green energy.

Hydroelectric Energy

Kinetic energy in flowing water or the potential energy in water reservoir is a conventional source of energy. In hydroelectric power plant, the potential energy in water stored in dam is converted into kinetic energy of water. Fast flowing is brought from the dam to the turbine at the bottom of the dam. The kinetic energy of the flowing water drives the turbine. The turbine in turn drives the generator to generate electricity.

The block diagram showing different components of hydroelectric power plant is shown in figure 5.15



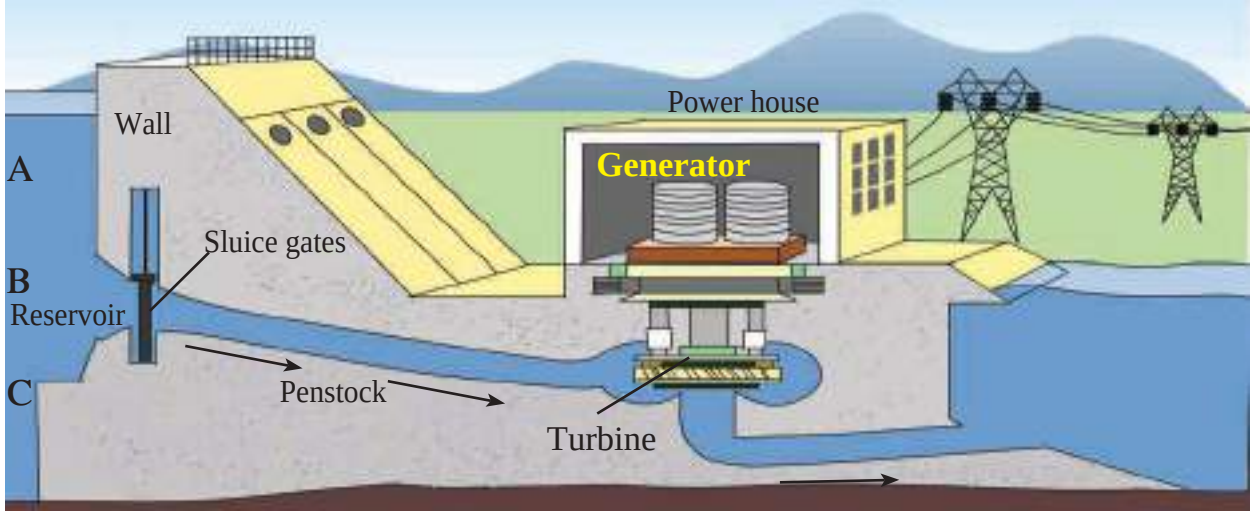
5.15 Different Stages in hydroelectric power plant

Electricity generation using wind-energy

Potential energy in water → Kinetic energy in flowing water → Kinetic energy in turbine → Electrical energy

5.16 Energy Transformation in hydroelectric powerplant

The schematic of hydroelectric plant is shown in Figure 5.17. Water from about middle of the total height of the dam is taken to the turbine, as shown by point B in the diagram.



5.17 Schematic of Hydroelectric plant

Use your brain power

1. With reference to point B, potential energy of how much water reservoir in the dam will be converted into kinetic energy?
2. What will be the effect on electricity generation, if the channel taking water to turbine starts at point A?
3. What will be the effect on electricity generation, if the channel taking water to turbine starts at point C?

Since no fuel is burnt in hydroelectric plant, no air pollution due to combustion of fuel results. However, considering the issues like forced migration of large community, submerging of forests and fertile land, adverse effect on living creatures in the river, it has always been a point of debate whether the hydroelectricity is environment friendly or not. What is your opinion about it?

Advantages of hydroelectric power generation

1. Since no fuel is burnt in hydroelectric power generation, there is no pollution resulting from combustion of fuels.
2. If there is sufficient water storage in the dam, it is possible to generate electricity as and when necessary.
3. Although water reservoir is used for power generation, it can be replenished during rainy season leading to uninterrupted power generation.

Problems associated with hydroelectric power plant

1. The back-water due to storage of water in dam may submerge villages or towns in that area. This leads to the problems of re-habitation of the displaced population. Moreover, this can also submerge forests as well as fertile land.
2. The obstruction of the flow of river water may have adverse effect on living world in the river.

Do you know?

Some major hydroelectric plants in India and their capacity (MW)

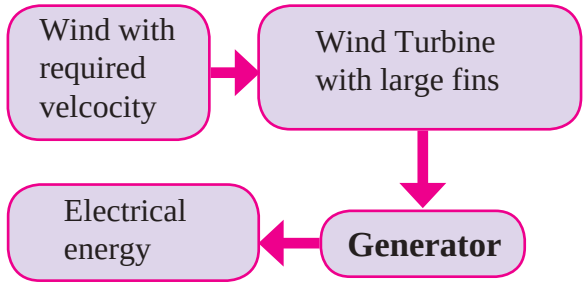
Place	State	Capacity (MW)
Tehari	Uttarakhanda	2400
Koyana	Maharashtra	1960
Srishailam	Andhra Pradesh	1670
Nathpa Zakri	Himachal Pradesh	1500

5.18 Koyana Dam

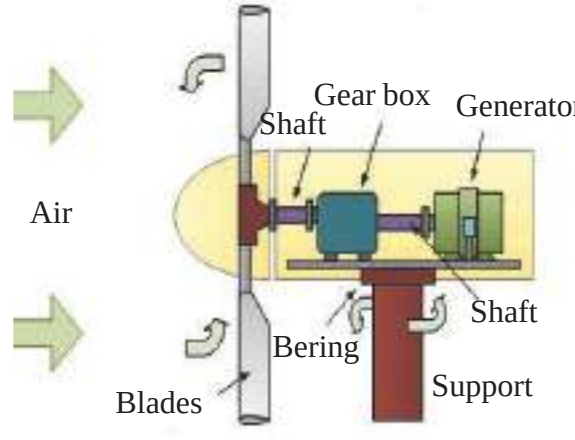
Find out

What is lake tapping? Why it takes place?

The kinetic energy in wind has been used since long for lifting of water, for driving floor mill etc. The wind energy can also be used for electricity generation. The machine which converts the kinetic energy of wind to electrical energy is called wind-turbine. As the wind strikes the blades of the turbine, the blades rotate. The axel of the turbine is connected to electric generator through a gear-box. The function of the gear-box is to increase the rotations per unit time. Thus, the rotating blades drive the turbine and the turbine in turn drives the generator to generate electricity. Various stages in the wind-energy generation system can be shown in figure 5.19 and schematics of a wind mill is shown in figure 5.20.



5.19 Stages in electric generator using wind energy



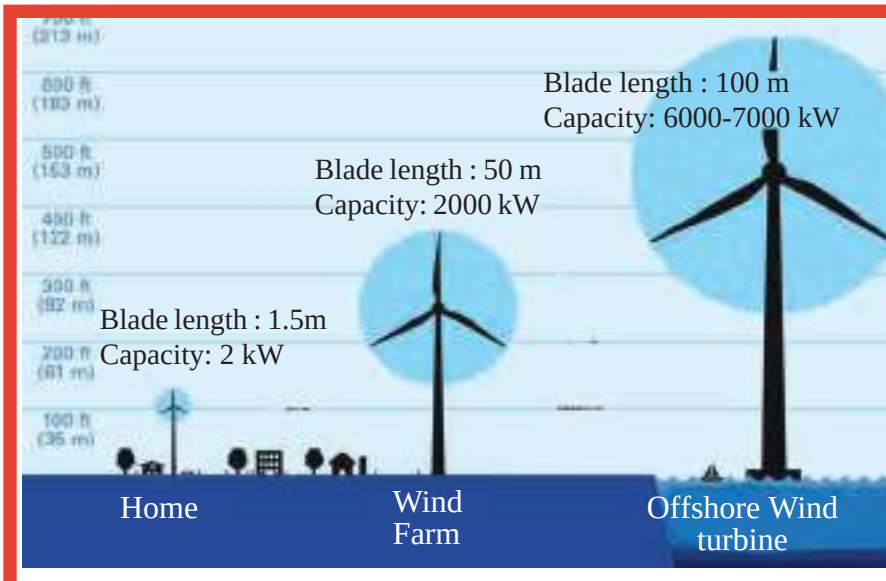
5.20 Schematic of wind mill

The energy conversion process is shown in figure 5.21.

5.21Transformation of energy in an electric generator using wind energy

Wind turbines with capacity right from less than 1 kW to about 7 MW (7000 kW) are commercially available. Depending on the wind velocity available at the site of installation, wind-turbine with specific capacity is selected. The wind velocity at specific location depends on many geographical factors.

Wind velocity is usually high on sea shores and that environment is appropriate for installation of wind turbine.Wind-energy is a clean energy source. However, the wind-velocity necessary for wind-energy generation is not available everywhere. In that sense, use of wind-energy is limited.



5.22 Wind turbines of different capacities

Get information

Get information about major wind-power stations in India and their capacity. Make a table of their location, state and their power generation capacity in MW.

Electric Energy generation using solar energy

Using the energy in the Sunlight, electric energy can be generated in two ways:

1. In all the above methods of electricity generation we have studied, the electric generator is driven by using some source of energy and electricity is generated by making use of the principle of electromagnetic induction. However, electrical energy can be generated directly from solar radiation without using generator and without using the principle of electromagnetic induction. This happens in solar photovoltaic cells. Solar photovoltaic cells convert the solar energy directly into electrical energy.
2. In the second method, the energy in solar radiation is converted into thermal energy first. Then a turbine-generator system is driven using that thermal energy to generate electricity.

1.Solar photovoltaic cell

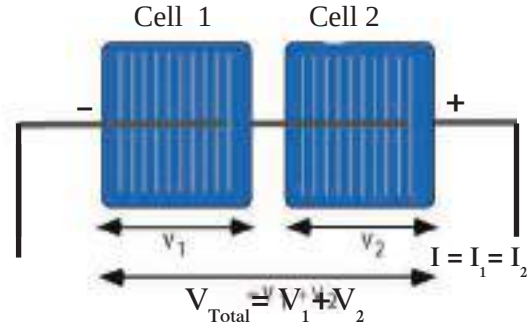
Solar photovoltaic cell converts the solar radiation energy directly into electrical energy. This is called solar photovoltaic effect. The electrical energy generated through this energy transformation process is DC in nature. These solar cells are made of a special type of material called semiconductor (e.g. silicon). A silicon solar cell of dimension 1 cm^2 generates current of about 30 mA and potential difference of about 0.5 V. Thus, a silicon solar cell of dimension 100 cm^2 will generate about 3 A (30 mA/cm^2 X 100 cm^2=3000 mA= 3 A) current and 0.5 V. Remember taht the potential difference available from a solar cell is independent of its area.

Energy in Sunlight —(Photovoltaic effect)→ **DC Electric power**

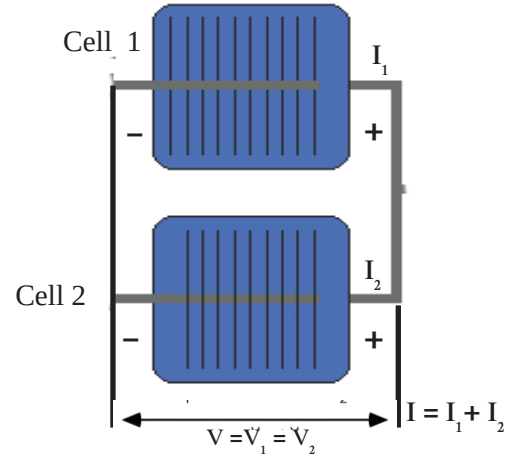
If two solar cells are connected in series as shown in figure 5.23, the potential difference obtained from this combination is addition of the potential differences of individual solar cells. However, the current generated from this combination is equal to the current from an individual cell. It means that when solar cells are connected in series, currents from the individual cells are not added. Similarlyas shown in figure 5.24, if two solar cells are connected in parallel, the current generated from this combination is the summation of the currents from an individual solar cells. However, the potential difference obtained from this combination is the same as the potential difference obtained from individual cell. Thus, if two solar cells are connected in parallel, the potential differences from the two cells are not added.

In this way, by connecting many solar cells in series and in parallel solar panels generating required current and potential difference are made. See Figure 5.25. For example, if 36 solar cells, each of size 100 cm^2 are connected in series in a solar panel, it will give potential difference of 18 V and current of 3 A. Many such panels are connected together to generate electricity on larger scale. A good solar cell can have an efficiency of around 15%. It means that if a solar panel receives power of 100 watt from solar radiation, the electrical power output from the panel will be 15 watt.

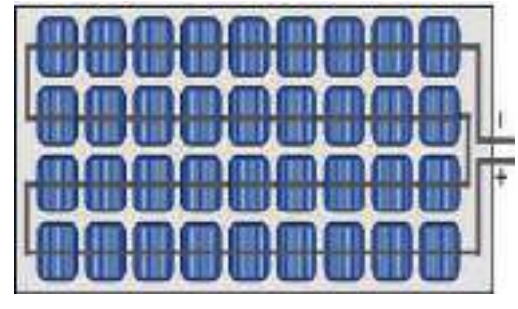
Many solar panels are connected in series and in parallel to generate required current and potential difference. As shown in Figure 5.26, solar cell is the basic unit in solar electric plant . Many solar cells come together to form a solar panel. Many solar panels connected in series form a solar strings, and, many solar strings connected in parallel form a solar array. As we can obtain as much electrical power as needed, they are used in applications which need marginal power (e.g. calculators that run on solar energy) to power station of MW capacity.



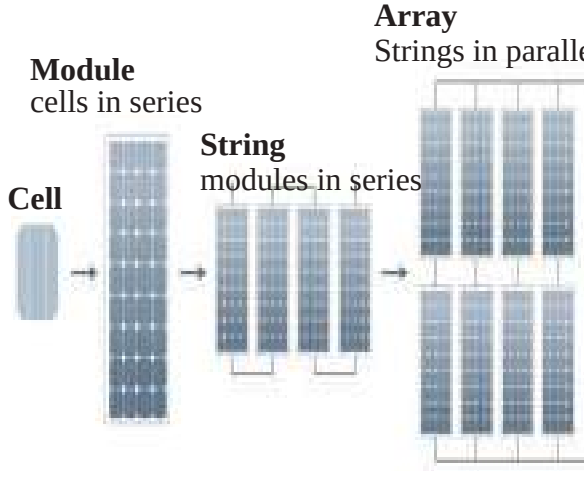
5. 23 Solar cells in series



5.24 Solar cells in parallel



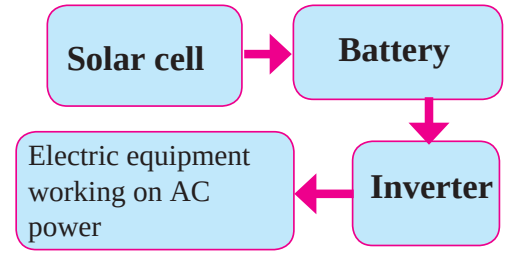
5.25 A solar panel made from 36 solar cells



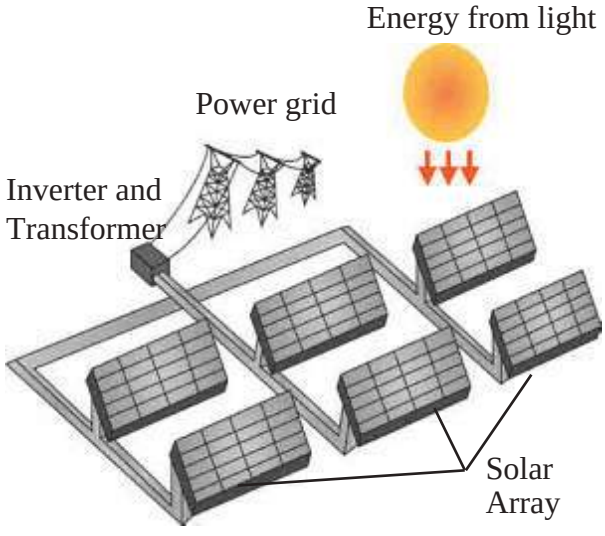
5.26 Solar cell to solar array

The power available from the solar cells is DC. So, in applications which need DC power , e.g. electric lights based on Light Emitting Diodes, the energy can be directly used. However, since the energy from solar cell is available only in presence of sunlight, the energy has to be stored in batteries for use at later time.

However, most of the equipment in domestic as well as industrial use run on AC power. In such case, the DC solar power must be converted to AC power using an electronic device called inverter(Figure 5.27).



5.27 Conversion of energy generated by cells to AC form by using inverter



5.28 Schematic of solar photovoltaic station

We have seen that many solar panels can be connected together to generate whatever energy we need. As shown in Figure 5.28, the DC power generated from these panels is first converted into AC power. A transformer transforms the voltage and current levels of the generated power and then it is fed into the electricity distribution network. Figure 5.28 is a schematic diagram of solar photovoltaic power station.

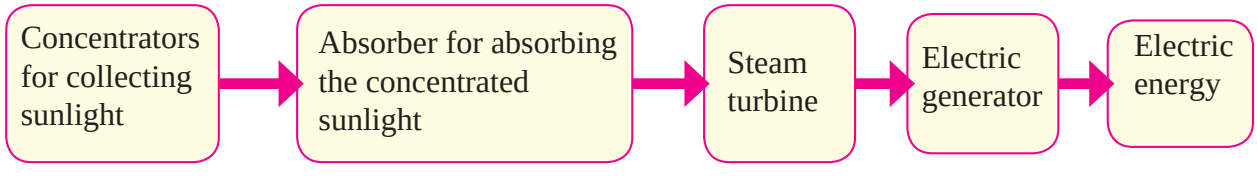
In this way, electricity is generated without any fuel combustion and so without any air pollution. However, since the energy is generated using solar radiation, solar cells can generate electricity during day-time only.

Find out

Gather information about major solar photovoltaic power generating plants and their capacity in India.

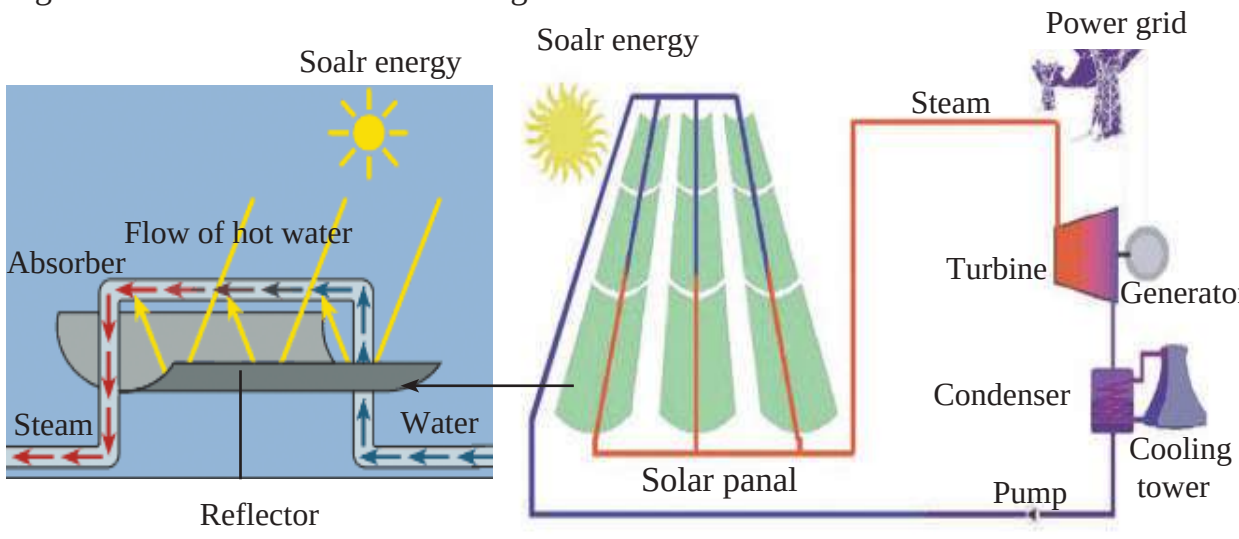
Solar Thermal power plant

We have seen that thermal energy generated from coal and nuclear fuel can be used to generate electricity. Thermal energy can also be generated from solar radiation and can be used for electricity production. Different stages in such solar thermal power plant are as shown in figure 5.29



5.29 Different stages in solar thermal power plant

As shown in Figure 5.30 , many reflectors reflect and concentrate solar radiation on absorbers. There solar energy is converted into heat energy. Using this heat energy steam is generated to drive the turbine and generator.



5.29 Schematic o fsolar thermal power plant

Do you know?

Energy sources use for electrical power generation in the world.

Souces	World (%)	India (%)
Coal	41	60
Natural Gas	22	08
Hydroelectric	16	14
Nuclear energy	11	02
Petrolium	04	0.3
Renewable sources (wind, solar etc)	06	15.7
Total	**100**	**100**

Exercise

1. **Remake the table taking into account relation between entries in three columns.**

I	II	III
Coal	Potential energy	Wind electricity plant
Uranium	Kinetic Energy	Hydro electric plant
Water Reservoir	Nuclear Energy	Thermal plant
Wind	Thermal Energy	Nuclear power plant

2. **Which fuel is used in thermal power plant? What are the problems associated with this type of power generation?**
3. **Other than thermal power plant, which power plants use thermal energy for power generation? In what different ways is the thermal energy obtained?**
4. **Which type/types of power generation involve maximum number of steps of energy conversion? In which power generation is the number minimum?**

5. Solve the following crossword puzzle.

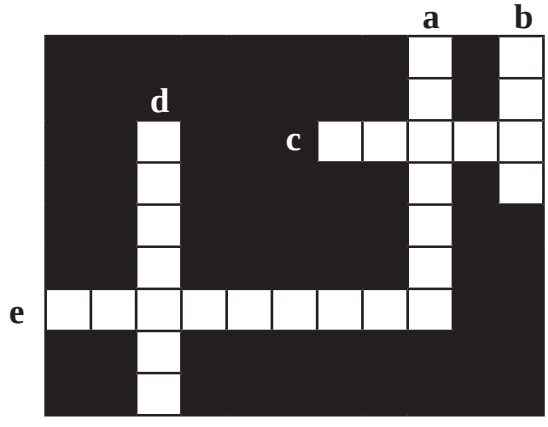
a. Maximum energy generation in india is done using..... energy.

b. ..... energy is a renewable source of energy

c.Solar energy can be called.... energy.

d .... energy of wind is used in wind mills.

e. ..... energy of water in dams is used for generation of electricity.



6. Explain the differance.

a. Conventional and Non-conventional Sources of energy.

b Thermal electricity generation and solar thermal electricity generation.

7. What is meant by green energy? Which energy sources can be called as green energy sources and why? Give exampls.

8. Explain the following sentences.

a. Energy obtained from fossil fuels is not green energy.

b. Saving energy is the need of the hour.

9. Answer the following questions.

a. How can we get the required amount of energy by connecting solar panels?

b. What are the advantages and limitations of solar energy?

10. Explain with diagram step-by-step energy conversion in

a. Thermal power plant

b. Nuclear Power Plant

c. Solar thermal power plant

d. Hydroelectric power plant

11. Give scientific reasons

a. The construction of turbine is different for different types of power plants.

b. It is absolutely necessary to control the fission reaction in nuclear power plants.

c. Hydroelectric energy, solar energy and wind energy are called renewable energies.

d. It is possible to produce energy from mW to MW using solar photovoltaic cells.

12. Draw a schematic diagram of solar thermal electric energy generation.

13. Give your opinion about whether hydro electric plants are environment friendly or not?

14. Draw neat and labelled diagrams.

a. Energy transformation in solar thermal electric energy generation.

b. One solar panel produces a potential difference of 18 V and current of 3A. Discribe how you can obtain a potential difference of 72 Volts and current of 9 A with a solar array using solar panels. You can use sign of a battery for a solar panel.

15. Write short note on

Electrical energy generation and environment.

Project :

1.Gather information about solar light, solar water heating system and solar cooker.

2.Gather information about a power plant near your locality by vising the plant.

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