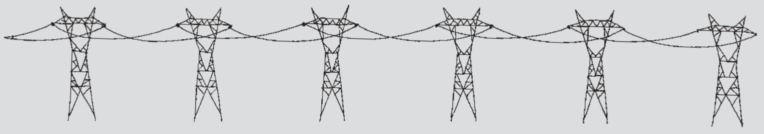
ENERGY ACTIVITIES

Energy Relay

The first law of thermodynamics states that energy is neither created nor destroyed but it may be transformed from one type of energy into another form. For example, the radiant energy of the sun is converted into the chemical energy of green plants. Dead plants, when subjected to heat and pressure over millions of years turn into coal. The chemical energy of coal is converted into thermal energy when coal is burnt. The thermal energy is used to convert water into steam, which can turn a turbine to generate electricity.

Quality of energy is the ability of energy to do useful work— that is, to heat, move or change the physical and chemical form of matter. High quality energy is concentrated as in electricity, oil, gas and coal, and has greater ability to perform work. Low quality energy is unconcentrated and diffused, such as low temperature heat. In spontaneous flows of energy, its quality always diminishes. For example, when high quality electrical energy flows through the filament of a light bulb, only 5 per cent of the energy is converted to light. The rest is converted to low-quality heat which is lost to the surroundings as waste heat. Once dissipated, this heat cannot be gathered up and recycled.



The second law of thermodynamics states that no energy transformations are hundred per cent efficient. This means that during any transformation, not all of energy is necessarily transformed into the desired form. For example, when the thermal energy of coal is used to boil water to convert it to steam, only part of the thermal energy does so. The rest is dissipated into the environment as waste heat. Unlike the quantity of energy which is conserved, the quality of energy is not. Instead it declines.

Objective

To help students understand that energy is lost as it passes along, from the source to the end user.

Subject
Science

Place
Outdoor

Duration
30 minutes

Group size
10-15 students

Materials
Two transparent tumblers or cups of the same size for every 15 students, spoons (one for each players), measuring cylinder

Activity

1. Ask the students to stand in a line. The line should have about fifteen players. (If there are many more than fifteen players, make them stand in two or more lines of fifteen players each).
2. Ask a student to pour 50 ml of water using a measuring cylinder into a cup. Take the cup around so that all the students can see the water level.
3. Give the cup of water and a spoon to the first player in the line. Give an empty cup and a spoon to the last player in the line. Give one spoon to each player in the line.
4. Ask the first player to take a spoonful of water from the cup and transfer it to the second player's spoon. The second player then transfers the water he/ she received to the third player in the line. After this transfer, the second player gets another spoonful of water from the first player. Meanwhile, the third player passes the spoonful of water to the fourth player and so on. The last player receives water in his/ her spoon and empties it into the cup that he/ she holds.
5. After all the water has been emptied into the last player's cup, call the students and ask any one of them to measure, using the measuring cylinder, the amount of water. Show the measuring cylinder to all the players so they can make a note of the amount of water in the last cup.
6. Discuss with the students as to what happened to the missing spoons of water.
7. Explain that each spoon of water represents a quantity of energy, and that loss of energy takes place with every transfer.
8. Explain that this energy loss occurs during the processes of extraction, processing, concentrating and transporting it to the user.

Extension/Variation

- Each line of students can be a 'team'. The game can then be an 'Energy Relay Race' with each team trying to complete the transfer of water with the minimum loss within a stipulated time.
- The game can also be played in two rounds, with the players taking care to minimize loss in transfer.

Exploring Your Power House

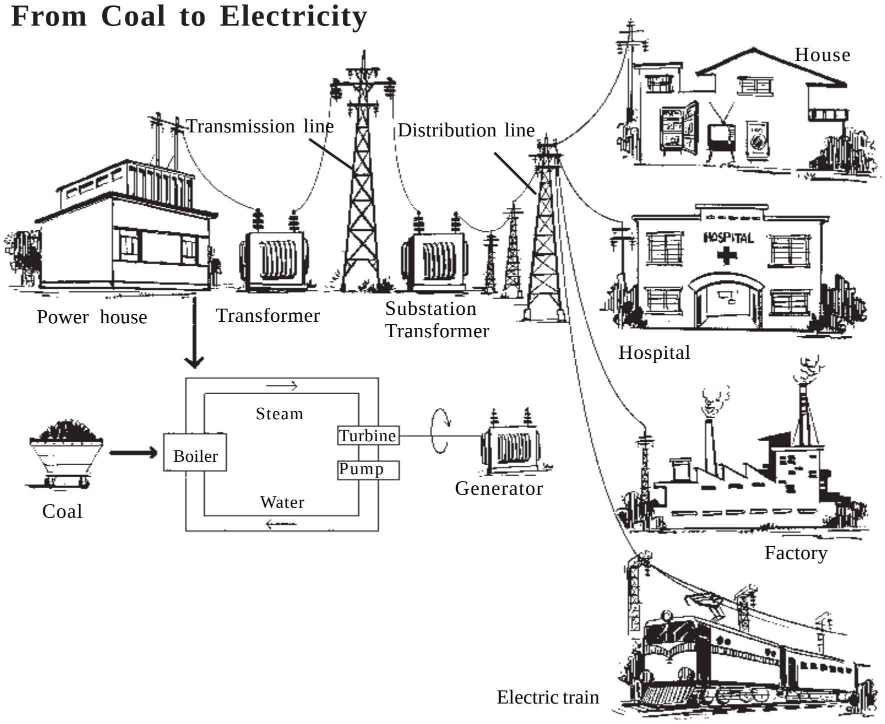
In India the major sources of power generation are thermal, hydroelectric, and nuclear. India is expected to depend on coal based thermal power generation for the next 100 years. Lately non-conventional energy sources, particularly wind energy, have also become important.

Electricity is the most convenient and versatile form of energy. It plays a key role in the industrial, agricultural and commercial sectors of economy and is also a crucial source for supplying domestic energy requirements. Despite a substantial increase in electricity generation, energy shortages affect all sectors of the Indian economy. The extent of transmission and distribution losses in generation—over 20 per cent of gross generation—remains an issue of serious concern.

Objective

To help students understand how electricity is produced and how it reaches our homes, through a visit to the local power station.

From Coal to Electricity



Subject
Science

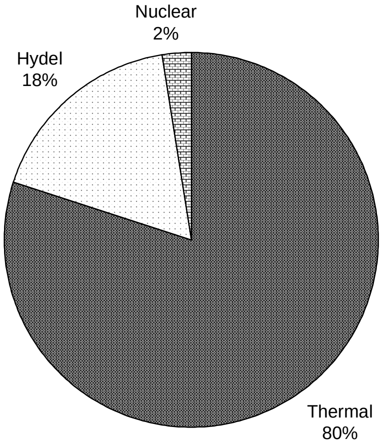
Place
Classroom and a field visit

Duration
A day visit

Group size
Entire class

Materials
Writing materials

Sources of Electricity Generation in India



Source: CEA and http://www.indiainfoline.com/infr/stat/gene/summ.html as on 26.03.03

Activity

1. Take the students on a tour to the power company that supplies power to your area.
2. Ask the students to find answers to the following questions during their visit to the power company.
   a. How is energy generated? (Note down the various steps involved in a notebook)
   b. What are the environmental impacts of this mode of electricity generation?
   c. Has there been significant change in the supply/ demand?
   d. How have costs to consumers changed in the last 10 years?
   e. Has the company modified operating methods in the last 10 years to address environmental issues?
   f. Are there any specific programmes/ schemes by the power company to promote energy conservation?
   g. How much are the transmission losses estimated to be? How and where do they occur?
   h. What is the efficiency of generation of power from the source?
3. Ask the students to find out how electricity reaches their home from the power station.

Extension/Variation

Ask the students whether there are any alternative sources of power generation possible for their town, which could mitigate the negative impacts of the current source.

Ask the student to bury leaves, banana peels etc., in the ground and watch for chemical changes in them (decaying leaves, a banana peel turning brown). Discuss what happens to plants after they die and fall to the earth. Ask the students how they think coal was formed in the earth. Show a lump of coal to the students. Inform them that it was once a part of a plant.

Ask the students to describe how coal and petroleum were formed millions of years ago.

Locate the Power Plant

Activity

Energy requirements are increasing sharply because of rapid industrialization, mechanization, urbanization, commercialization, population growth and changing lifestyles. Since the supply of energy is not keeping pace with the rising demand, energy shortages are experienced in everyday life. These are manifested as shortages of petrol, electricity, cooking gas and fuelwood.

Given the fact that the energy resources we depend on today are non-renewable, and that their use has negative environmental impacts, there is need to shift to renewable energy sources. India is well endowed with renewable energy sources. The exploitation of this potential depends upon it being acceptable in planning, its cost, and the electricity supply network being able to accept its output.

Subject
Science, Social Science

Place
Classroom

Duration
45 minutes

Group size
8-10 students

Materials
Writing materials

Objective

To help students understand that various factors need to be considered in planning any project, and that decision making in real life is a complex process.

Activity

Photocopy or write each role on a separate slip of paper. Assign these roles to six students and distribute the slips according to their roles.

If there are some extra students, ask them to act as "observers" or as "reporters". Ask the students to "get into" the character's role. Emphasize that the role-play is a serious session. Tell them not to share their roles with others in the group.

Read out the enclosed "Case of Rampur" and ask the students to get into their roles and discuss and evaluate each source, and the alternative options based on the criteria they think are important. Tell them they have half an hour for the discussion.

Ask them to come to a decision, after considering the following factors:

Sustainability of the source
Safety risk of the source
Pollution
Cost—both initial and recurring cost
Renewability
Ability to meet the increasing demand

After the role-play, which solution would be best for Rampur? Ask them to explain their decision.

Ask the observers/reporters if any, to report their observations on the process.

Case of Rampur

You are residents of a state where 'Rampur', a booming industrial locality is situated. You must, in the capacity of the roles assigned to you, evaluate several proposals for dealing with a growing shortage of electricity.

The Scenario

"Rampur" is enjoying a period of economic growth that most places can only dream about. Rampur has grown from a sleepy little rural locality to a booming place with plenty of jobs and high standards of living.

The place has a large beautiful Revati Talav (lake) which has a lot of migratory birds visiting it during various seasons. Nandhini, a large river, which is a major source for irrigation, flows nearby. It becomes dry during severe summer.

Rampur luckily, has avoided problems like crime and pollution that plague many other communities during their boom periods. It has become a place where people want to live and where businesses want to come. As a result, the population has increased fivefold during the last 25 years. Yet electricity is produced in a power plant built in 1949 designed for a much smaller population. During the heat wave last summer, many air-conditioners, air coolers and refrigerators were turned on and power shortages occurred all over the place. It is feared that the situation will get worse in the future. If the situation continues, industries may no longer be attracted to Rampur.

The Chief Minister of the state has called for a cabinet meeting with all members concerned, and she has also invited leading industrialists and research scientists from across the state, working on various aspects of energy, for technical assistance and clarifications. Through this meeting, she plans to decide on the type of energy source to depend on for generating further power for Rampur.

The Roles

(Write each role on a separate slip of paper and give it to the student to whom the role has been assigned.)

Chief Minister

You are a sincere and shrewd politician. You wish to help Rampur to develop further, by setting up a power plant—more so because you have invested a large share of your earnings on industries in Rampur. You are also concerned about the environment in general, and that of Rampur in particular.

Minister for Energy

You are a sincere minister who wants development to occur in Rampur. By setting up a large power plant, you plan to increase your popularity in the state. You want to ensure that you get re-elected in the elections scheduled in the coming year. You are of the opinion that setting up a large dam across the River Nandhini that flows close to Rampur is a good option. You have plans to give employment to people who get displaced, in industries that would experience growth and the new industries that would be set up, or give them land to take up agricultural activities in the nearby villages. Setting up of a large dam would ensure your name gets popularized and it will boost irrigation to farmers during summer.

Minister of Industries and Mines

You are a popular politician, who would like to take the Chief Minister's chair and are aiming for more popularity in the state. You are not concerned about the source of power. Your only concern is that the proposed plan should provide maximum employment to people around, since neither has any new industry or mine been set up during your tenure as Minister of Industries and Mines, nor were you able to introduce any new tax rebates for industries. You are worried that you are slowly losing your popularity with industrialists, as power needed for industries is not available in sufficient quantity.

Leading Industrialist

You are one of the leading industrialists in the country. You are totally against the idea of energy conservation. In your opinion, industries need more energy. According to you, even a little conservation in the industrial sector means making a sacrifice, in terms of quality and the production rate. This means reducing the growth rate and progress of Rampur and the state.

During your recent visit abroad, you have observed a large number of nuclear power plants which do not let out any smoke as the present thermal power plant in Rampur does. You strongly feel your state should also go for a nuclear power plant, as it is least polluting to the environment.

Coal

The main advantage of coal is relative abundance, more than any other source, with a supply for more than 100 years at today's rate of use. The primary disadvantages are the dangerous nature of coal mining, pollution from ash, and sulphur dioxide emissions, which can cause acid rain.

Nuclear

The advantages include the potential to produce energy with low fuel costs and no air pollution. The disadvantages are the lack of foolproof technical know-how in operation, exposure to radiation to workers in nuclear power plants, disposal problem with the radioactive waste and the possibility of a catastrophic accident.

Solar

Advantages include low operational costs and no pollution. But solar power is land-intensive, with high initial expense and needs some kind of storage facility, for the lack of sunlight at night. Further, output depends on the weather, requiring sunny days.

Hydroelectricity

The principal advantages are that it is pollution free, renewable and relatively cheap. On the other hand, making dams is land-intensive, involves very high initial expense, requires abundant supply of water (which is seasonal in most parts of the country), disturbs the natural ecosystem, is highly prone to natural disasters like earthquakes, etc., causes waterlogging in areas nearby, is subject to problem of siltation, and involves resettlement of many people in the submergence area of the dam.

Environmentalist

You are a very concerned environmentalist. You feel that with more development, Rampur's environment is getting increasingly degraded. The air that people breathe during peak hours in the place is equivalent to smoking a dozen cigarettes through the day! The air has become stale and the birds that visited the beautiful Revati Talav (lake) nearby are slowly decreasing in number. You are of the opinion that actually, very little power is needed for the sustainable growth of the place. You are of the strong opinion that setting up of solar power generating units in the vast wasteland nearby, coupled with conservation measures by one and all, could easily solve the current crisis.

Research Scientist

You are of the opinion that setting up a new power plant could be postponed. You are of the strong opinion that conservation can stretch the energy resources, reducing or eliminating the need for additional energy generating capacity. However, this could happen only if people in all the sectors—industrialists, farmers and the common public—adopt energy conservation measures. You know that average efficiency of power plants is only 44 per cent and transmission losses as high as 22 per cent. You feel that Ministry of Power should focus on ways to reduce these. Also you feel that industries by using more efficient processes and technologies can cut down energy use. You are of the opinion that people are getting too Westernized by blindly imitating the western power-intensive culture. You are aware of the advantages and disadvantages of each of the sources.

Observers/Reporters

You are designated as an Observer/ Reporter for this meeting by the Chief Minister. You are supposed to observe and record all actions and points that help the group to reach the solution during the discussion. You should not voice your opinion or make comments that would distract the others.

A Box of Sunshine

Activity

India receives 5000 trillion kWh of solar radiation per year. In most parts of the country, out of the 365 days, 300 are sunny days. With the sunshine India receives, it is possible to generate 20MW solar power per square kilometer of land. Solar energy has been in use in India from time immemorial for several domestic, agricultural and manufacturing purposes, including preservation, protection, and processing of foods, e.g., preserving pickles and spices, and drying clothes.

In India, a major part of the energy in the household sector is used for cooking. It has been estimated that within the household sector, cooking accounts for over 90 per cent of the energy consumed. Therefore, it is important to consider conservation in this sector. This is where solar energy can come in useful.

In recent times, in India as the world over, there has been an increased thrust on research and development on technologies and devices to harness the sun's energy efficiently. The solar cooker is one such device. This works on the principle of Greenhouse Effect. In a solar cooker, a blackened sheet is placed inside an insulated box, lined with silver foil on the inner side, and the open face of the box is covered with a glass sheet. This helps in maximizing the absorption of heat and minimizing heat losses due to reflection. When such a solar cooker is kept in the sunlight, the inner surfaces heat up after absorbing solar energy. As a result, these surfaces start radiating heat in the form of infrared radiation. But the glass sheet above prevents the radiation from escaping and thus helps in retaining the heat inside the box.

A solar cooker has the advantage that it helps to reduce the consumption of conventional fuel and electrical energy. It does not pollute the environment. As it is a slow cooking device, it preserves the nutritional value of the food. It is also easy to operate and helps save money. Conventional cookers require fuels like LPG, kerosene, firewood. Cooking on conventional cookers needs constant attention in terms of switching of the gas when food is cooked. There are also risks—of gas leaks, of the stove bursting, etc. Solar cookers are free from all these risks.

Till now, about 5,15,000 solar cookers have been installed in India. While this is a good beginning, there is a great scope for improvement.

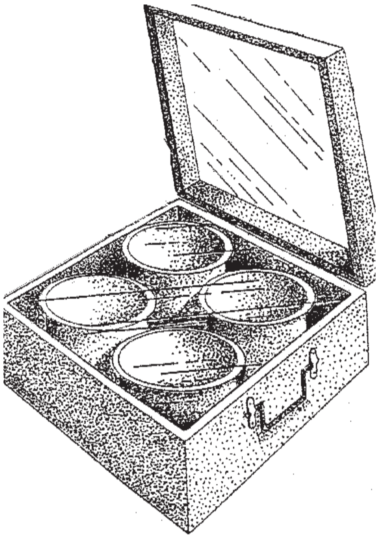
Subject
Science

Place
Inside the classroom and outside

Duration
30 minutes to 1 hour (plus cooking time)

Group size
Whole class or group of 10 students

Materials
See box " Making a solar cooker"



Objective

To enable students to

- Construct a lightweight portable solar cooker.
- List the advantages and disadvantages of cooking food in a solar cooker.

Procedure

1. Ask the students to find the name of a kitchen appliance which fits the following description:

   "Easy to use, produces no smoke, can be used many months of the year, requires no fuel or chemicals, and costs nothing to operate".
2. Discuss all the answers given, and how they may not fit every characteristic in the description. The correct answer is of course, a solar cooker.
3. Ask the students to build a solar cooker according to the instructions given in the box 'Making a Solar Cooker'. Cook *khichdi* in the cooker in the school.
4. Discuss how a solar cooker can prepare food efficiently and at the same time promote good health and wise energy use.

Extension/Variation

Ask the students to list advantages and disadvantages of using a solar cooker.

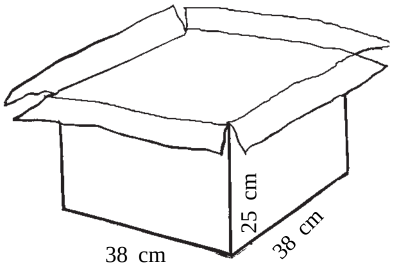
Ask each of the students to describe their experience with the solar cooker to their parents, and discuss with their parents the possibility of using a solar cooker at home.

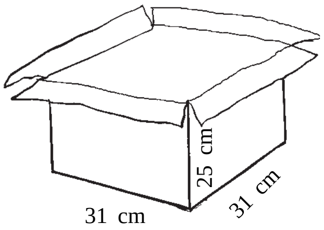
Making a Solar Cooker

Materials Needed

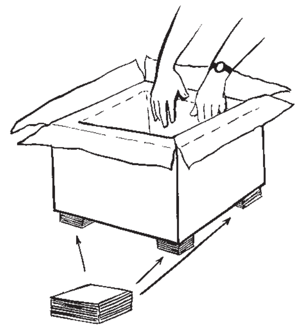
Two cardboard cartons (The first box should be approximately 38 cm x 38 cm, and of height 25 cm. The second box should be approximately 31 cm x 31 cm and about 3 cm shorter than the first box.), corrugated sheet, one sheet of cardboard to make the reflector (approximately 43 cm x 43 cm), silver foil (one roll), dull black paper, flower clips, thick transparent plastic sheet, scotch tape.

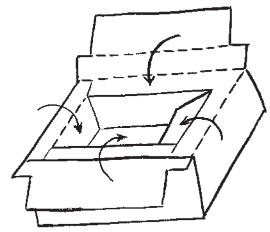
This model of solar cooker is based on having one box inside the other. The larger box of dimensions 38 cm x 38 cm x 25 cm will serve as the outer box, and the box of dimensions 31cm x 31cm x 25 cm will serve as the inner box.

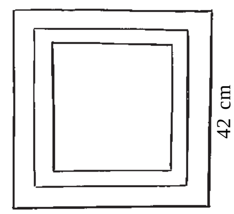


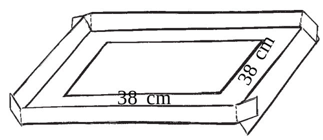


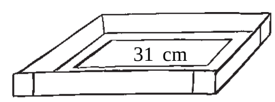
1. Paste silver foil on all the inside surfaces of the larger box.
2. Also paste foil on the inside and outside of the flaps (lid) of the outer box.
3. Paste black paper on the bottom of the inner box. On all the other inner surfaces of this box, paste silver foil.
4. Cut off the flaps of the inner box.
5. Make four 'legs' for the inner box by folding 4 pieces of corrugated sheet and pasting near the four corners at the bottom of the box. The height of the legs should be about 3 cm.
6. Place the smaller box inside the larger one. If the height of the inner box is more than that of the outer box, trim as necessary to bring them to the same height.
7. Fold the flaps of the outer box such that they cover the gap between the outer and inner boxes and can be folded down 2 cm into the inner box.
8. Hold tight and tape down securely, so that there is no gap. If there is extra length, trim it.
9. Now, cut a piece of corrugated sheet (approximately 42 cm x 42 cm) large enough to make a tight fitting lid for the outer box (38 cm x 38 cm).
10. Cut away a window of the size of the inner box (31 cm x 31 cm) from this piece of the sheet. Tightly tape a piece of thick transparent plastic over this window.
11. Paste silver foil on the inside of the lid (except where there is plastic).
12. Now fold and tape the edges of the corrugated sheet to make a tight fitting lid.
13. Take a piece of cardboard of 43 cm x 43 cm size to make a reflector. Paste silver foil on the inside.
14. Make hinges of cardboard and attach with flower clips to the lid and the reflector.
15. Take a piece of cardboard of 15 cm x 12 cm and make serrations as shown.
16. Tape securely, at the angle shown, to the outside of the box.
17. Make a firm prop using a folded piece of cardboard or a stick. The prop should be long enough to hold up the reflector at 45°.

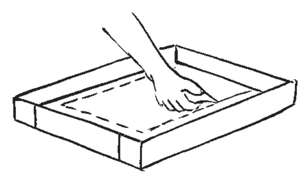


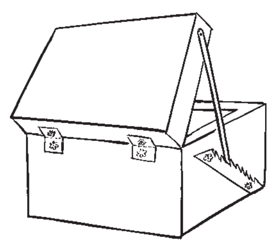












Activity

How Costly are My Habits?

Subject
Science, Social Science

Place
Indoor

Duration
30 minutes

Group size
Entire class

Materials
Two envelopes—one marked 'A' and another 'B' and 40 matchsticks per student.

Energy consumption in India is increasing rapidly. For instance, the commercial energy consumption increased from 130.7 million tonnes of oil equivalent (mtoe) in 1991-'92 to 176.08 mtoe in 1997-'98. In this situation, conservation of energy is an important value that we need to practice in our day-to-day life.

Another important factor we need to become aware of is that while most people are careful in their own homes, there is a tendency to be careless about energy conservation at other places like schools, institutions and offices, probably because we feel that we do not have to pay for the energy consumed. But someone is paying! Moreover, all of us have to pay for energy wasted in terms of environmental costs—the natural resources used and the pollution created. So, the perception of "energy for free" has to change, and the change needs to begin with today's students, who are tomorrow's decision-makers.

Objective

To help students understand the environmental and monetary costs of energy-related daily habits.

Procedure

1. Give each student two envelopes, one labelled, "A" and another "B".
2. Give each student 40 matchsticks, or ask them to collect 40 twigs from the school ground.
3. Tell them to consider the matchsticks or twigs as "play money" valued at Rs. 5/- each.
4. Tell the students that you are going to ask them several questions one by one. After each question, explain to the students that depending on their answer, you will give instructions on whether they should put money in the "A" envelope or the "B" envelope.
5. Tell the students that this game will help them to understand for themselves how much impact they have on the environment, so they should try to answer the questions sincerely, after sufficient thought.
6. Ask the students the "My Habits Cost" questions (given in box). Follow each question with instructions to the students as to whether

they should put their money in the "A" envelope or in the "B" envelope, and how much.

7. After asking all the questions and giving instructions, ask the students to count the money in each envelope.
8. Tell them that the "A" envelope represents the money saved by avoiding wastage of energy and "B" is the money spent on energy. Thus the students with more money in the "A" envelope are using energy wisely and benefitting both the environment and their pockets.
9. Explain to the students the "Why" of the answers (See "Reasoning Sheet" on page 117), for them to understand their energy-wasting habits and how they could save more for themselves.

Extension/ Variation

- Select questions on a variety of topics like water, energy, etc., to give a wider understanding of how an individual's actions have an impact on the environment.

My Habits Cost

a. Do you play more than one TV/ Music system in your house simultaneously at any time?

   Yes. Pay the "B" envelope Rs. 20/- for each appliance, from the second appliance onwards.

   No. Pay the "A" envelope Rs. 10/-.

b. Do you turn off the lights every time you leave your room?

   Yes. Pay the "A" envelope Rs. 10/-.

   No. Pay the "B" envelope Rs. 20/-.

c. Do you use a hair dryer in summer?

   Yes. Pay the "B" envelope Rs. 20/- for every time you use it in a week.

   No. Pay the "A" envelope Rs. 5/-.

d. Do you play video games?

   Yes. Pay the "B" envelope Rs. 10/-.

   No. Pay the "A" envelope Rs. 5/-.

e. Do you walk or cycle short distances rather than depending on a petrol/ diesel vehicle?

Yes. Pay the “A” envelope Rs. 5/-.

No. Pay the “B” envelope Rs. 20/-.

f. Do you eat your breakfast and dinner together with all the members in the family?

Yes. Pay the “A” envelope Rs. 5/-.

No. Pay the “B” envelope Rs. 10/-.

g. Do you travel by private vehicle (scooter or car) for reaching the school?

Yes. Pay the “B” envelope Rs. 20/-.

No. Pay the “A” envelope Rs. 10/-.

h. Do you keep the refrigerator door open while drinking water?

Yes. Pay the “B” envelope Rs. 10/-.

No. Pay the “A” envelope Rs. 5/-.

i. Do you operate appliances on battery instead of directly using the mains?

Yes. Pay the “B” envelope Rs. 20/-.

No. Pay the “A” envelope Rs. 5/-.

j. Do you use the lift for going downstairs?

Yes. Pay the “B” envelope Rs. 20/-.

No. Pay the “A” envelope Rs. 10/-.

k. Do you use natural light during daytime for activities like reading, writing, etc.?

Yes. Pay the “A” envelope Rs. 10/-.

No. Pay the “B” envelope Rs. 20/-.

l. Do you use incandescent bulbs at home?

Yes. Pay the “B” envelope Rs. 10/- per bulb used.

No. Pay the “A” envelope Rs. 5/- per fluorescent light bulb used at home.

Reasoning Sheet

a. A TV/ Music system consumes approximately 30 units of electricity every month, when used for one hour every day. You cannot enjoy two or more together. So it is a waste keeping more than one on.

b. Domestic light bulbs consume electricity ranging from 40 W to 100 W. On an average, almost 5 to 10 units (kWh) of useful energy is wasted every month in a home, by not switching off the lights when not needed.

c. A hair dryer consumes approximately 1 unit of electricity every time it is used. In our country, it is definitely not needed in summer.

d. Electronic video games not only consume electric power, they also make one sedentary, leading to health problems.

e. Cycling and walking are good for health. Also for this mode of transport, we do not need fossil fuel.

f. 50 per cent of energy consumed in India is used for cooking. Often in our homes, the food is reheated every time a person sits down to eat. Quite a lot of fuel is spent in this reheating. Moreover, every time the food is reheated, nutritive value of the food is lost. Eating together means less energy spent.

g. Most cars travel about 10 to 12 kilometres per litre. Assuming that 4 persons travel in a car, that makes 40 to 48 person kilometres. On the other hand public transport vehicles like buses, trains etc., travel 50 to 200 person kilometres for the same quantity of fuel.

h. A refrigerator consumes approximately 6 units of electricity for every hour its condenser works. Every time a refrigerator is opened, the cool air from the refrigerator moves out and the warm air from outside moves in. This means the condenser has to work longer.

i. The energy spent to manufacture a battery cell is more than the energy it supplies. Also, when disposed after use, the chemicals in these cells leak out and pollute the environment.

j. A lift is one of the high energy consuming devices often used by individuals. Walking downstairs is good exercise, so should be preferred.

k. In tropical countries like ours, abundant daylight is available throughout the year. Moreover, it is available free and does not use any of the earth's resources.

l. A 75 W incandescent bulb (filament bulb) consumes 7.5 units for running 100 hours, while a 15 W compact fluorescent light bulb (which gives the same amount of light as a 75 watt bulb) consumes only 1.5 units.

Measuring Energy

Joule (or J) is the basic metric unit for measuring energy. It equals 0.239 calories.

1 calorie is the energy required to raise the temperature of 1 gram of water by 1 degree Celsius

A widely used unit for measuring commercial energy is **MToE** (million tonnes of oil equivalent)

1 MToE=12,000 GWh=10.2 x 10^{12} kilocalories

Power is the rate at which energy is used, or energy per unit of time. The international unit of power is **watt** (W).

1 watt = 1 joule per second

Energy can also be measured in terms of power x time.

1 watt-hour is the amount of energy used to produce a power flow of one watt for one hour.

1 kilowatt-hour(KWh) = 1000 watt-hours = 3600 kilojoules (kJ) = energy used by one 100-watt bulb burning for 10 hours = 1 unit of power. (Our electricity bills charge us in terms of power).

1 kilowatt (KW) = 1000 Watts = power consumed by ten 100W bulbs.

Activity

Graphing Energy

Subject
Maths

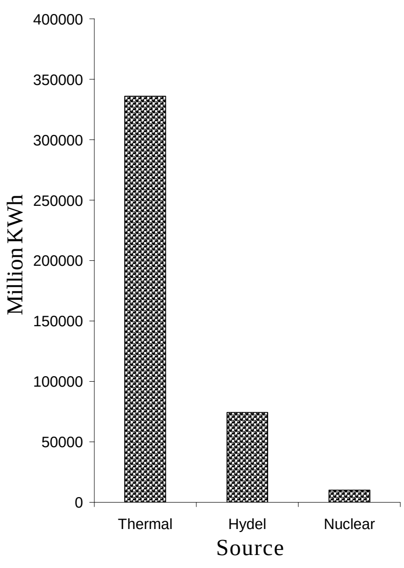
Place
Classroom

Duration
45 minutes

Group size
5 to 7 students

Materials
Writing materials

Power Generation in India (1998-99)



Source: CEA and http://www.indiainfoline.com/infr/stat/gene/summ.html as on 26.03.03

Information presented in the form of graphs is often easier to understand and remember than information presented as a mass of facts and figure. Graphs and charts communicate information visually. For this reason, graphs are often used in newspapers, magazines and businesses around the world. Sometimes, complicated information is difficult to understand and needs an illustration. Other times, a graph or chart helps impress people by getting your point across quickly and visually.

Compared to text, graphs are clear, concise, and quickly reveal the relationship between the various variables. There are three basic types of graphs that are most commonly used. These are as follows:

Pie Chart: A pie chart (sometimes known as circle graph), is used when parts of a whole are represented. These charts are especially popular when breaking down percentages. The whole circle represents 100 per cent, while each section represents part of the whole.

Bar Graph: A bar graph presents separate groups of information in a format that allows for comparison. The bars may be vertical or horizontal.

Line Graph: A third type of commonly used graph is a line graph. A line graph shows trends and is often used to show changes over time.

Objective

To help students

- Understand the importance and use of various types of charts and graphs
- Analyze some energy related data presented in graphs.

Activity

Read out the passage “Power Generation” below. Then show students the graph “Power Generation in India 1998-99”. Ask them which is easier to understand.

“Power Generation: The major sources of power generation are Thermal, Hydroelectric, and Nuclear. In 1998-99 about 336033 KWh (80 per cent) of the total power generated was thermal based, 74388 KWh (18 per cent) was hydro based and 9984 KWh (2 per cent) was nuclear.”

Now divide the class into groups of 5 to 7.

Photocopy the graphs given below and give one set to each group. Alternatively, reproduce them on the board or on a chart paper.

Tell the students that they are going to do a few exercises based on these.

Exercise I

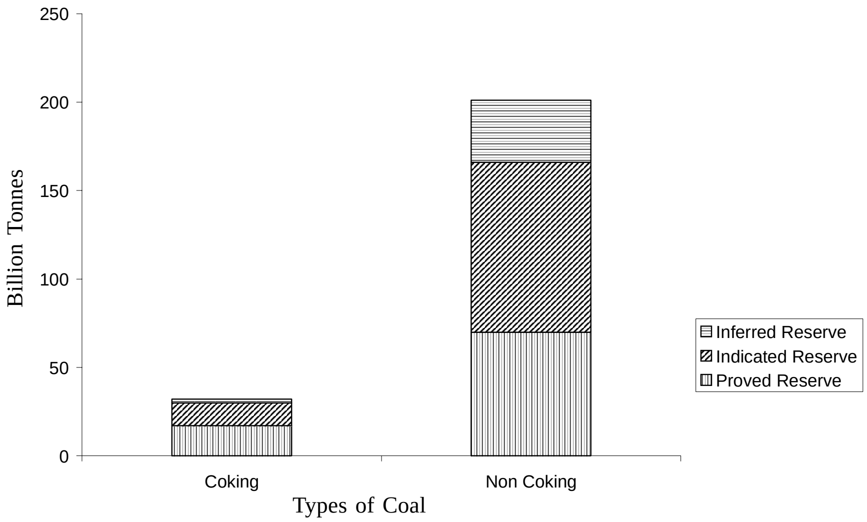
Ask the students to examine the following bar graph (Graph1) and answer the following questions.

a. Which type of coal is primarily found in India?

b. How many billion tonnes of non-coking coal does India definitely have?

c. What is the maximum amount of coking coal India may have?

Graph 1: Coal Reserves in India as on 1-1-2002



Source: www.coalindia.nic.in/coalreserve.htm

Exercise II

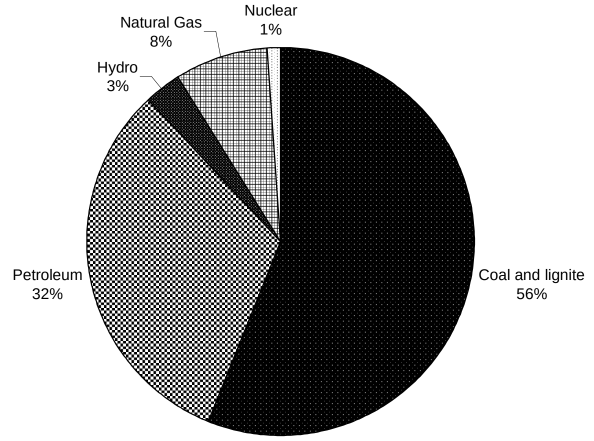
Ask the students to examine the pie chart given (Graph 2) carefully and state whether the following statements are true or false and to correct the false statements based on the information depicted in the graph.

a. Coal and lignite are the major source of energy.

b. The share of nuclear sources is greater than that of hydro.

c. Petroleum forms the third largest source of commercial energy.

Graph 2: Share of Energy Sources in Commercial Energy Consumption (1997/98)



Source: State of the Environment, India, UNEP 2001

Exercise III

Ask the students to examine the following bar graphs (Graph 3) and answer the following questions.

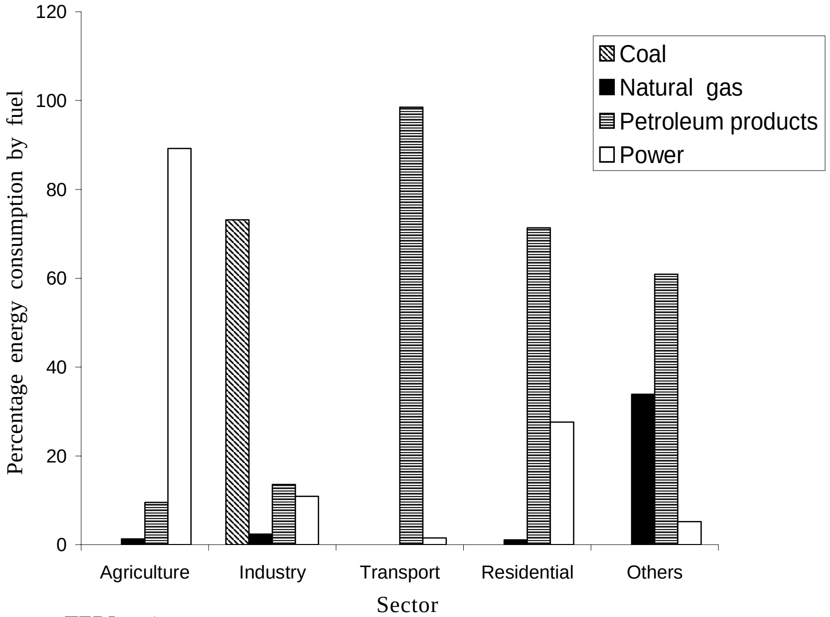
a. Which sector has consumed maximum coal?

b. Which sector consumed maximum petroleum products?

c. Which sector does not uses coal or natural gas as fuel?

d. Which types of fuel are insignificant in agriculture and domestic sectors?

Graph 3: Sectoral Energy Consumption by Fuel (%):1999/2000



Source: TERI estimates

Exercise IV

Ask the students to examine the pie chart given (Graph 4) carefully and state whether the following statements are true or false.

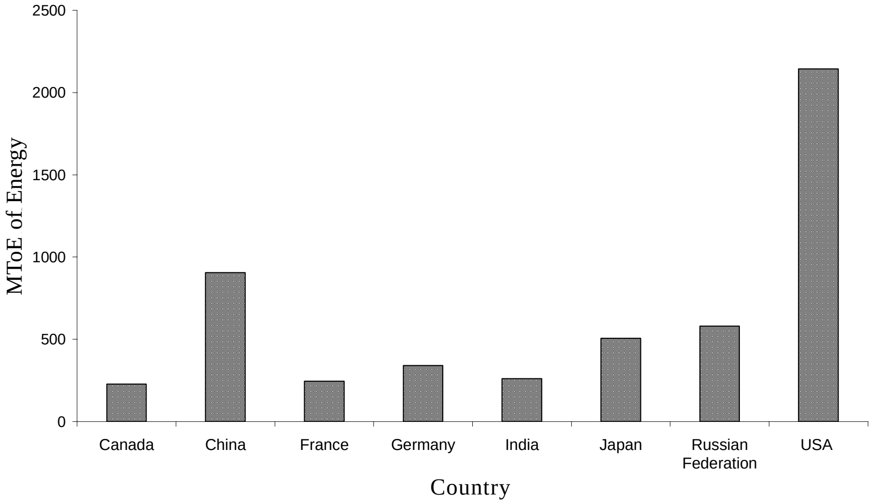
a. Domestic sector accounts for 15 per cent of the commercial energy consumption in the country.
b. Transport sector is the largest consumer of commercial energy.
c. Transport consumes more than agriculture and domestic sector together.

Exercise V

Ask the students to examine the following graph (Graph 5) and answer the following questions.

a. Which country consumes the maximum and the minimum energy?
b. Which three countries consume more than 200 MToE and less than 300 MToE of energy?
c. Which two countries consume more than 800 MToE of energy?

Graph 5: World Primary Energy Consumption for Selected Countries, 1997



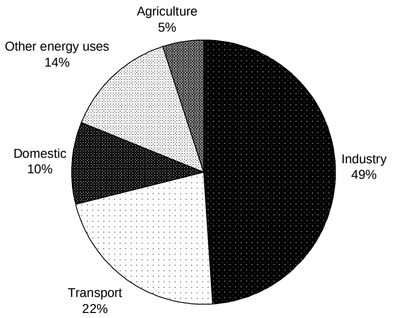
Source: Yearbook of Energy-Environment Statistics 1998, Bharat Information Technology Services

Exercise VI

Ask the students to examine the following line graphs (Graph 6) and answer the following questions.

a. In which year was there maximum crude oil production?
b. How much coal was produced in 1975-76 and in 1998-99? How much is the increase?

Graph 4: Sectoral Composition of Commercial Energy Consumption 1999/2000



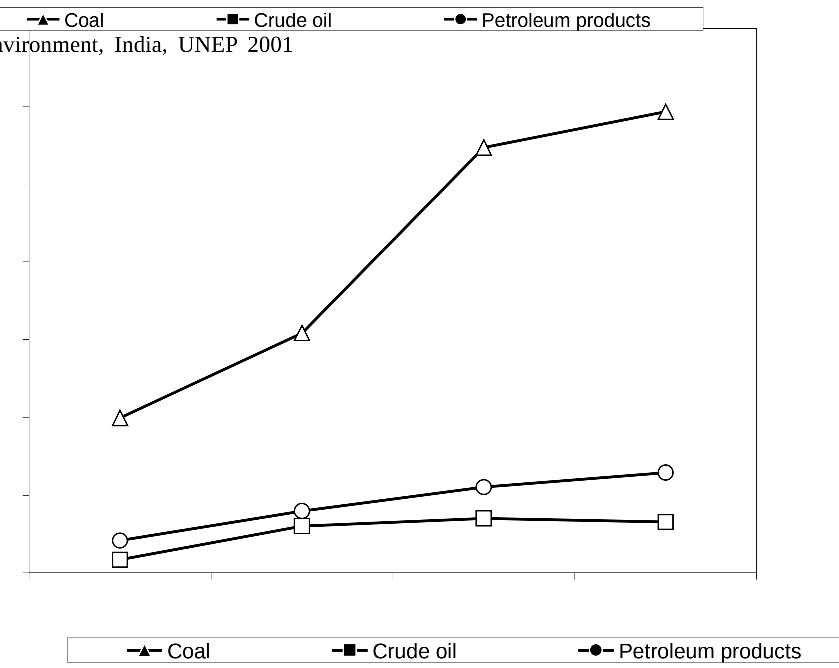
Source: TERI estimates http://www.teriin.org/energy/overvw.htm

c. How much is the increase in the production of petroleum products from 1975-76 to 1998-99?

Graph 6: Trends in Coal and Oil Production and Petroleum Products

Production in million tonnes

Year



Source: State of the Environment, India, UNEP 2001

More About Energy

Energy is all around us: in sunlight, in light bulbs and fans, in buses, cars and tractors, in T.V. sets, in the power of our muscles and in the food we eat. Energy is used to grow our food, to cook it, to keep us warm or cool, to move us from one place to another. It is a vital force in our lives. It is an essential ingredient of all activity on earth. Every technological advance in human history has, in a major way, been a result of our increasing ability to harness energy, convert it to useful forms and put it to various uses.

But the galloping increase in our use of energy has also created problems—some local, some global; some immediate, some looming ahead. For example, the increasing demand for fuelwood in rural and urban areas is contributing to degradation of forests in some parts of the country. The pollutants that the burning of fossil fuels add to the atmosphere are making the air unsafe to breathe. Because certain gases emitted by fuel combustion trap heat, experts predict that by the year 2100, average global temperature will have increased by anywhere between 1^{o} and 3.5^{o}Celsius. So it is important that we take a close look at energy—where it comes from, how we use it, what the environmental impacts are and what we can do about it.

> According to a newspaper report, in Mexico City, the air was unsafe to breathe for more than 300 days in 1990. In New Delhi the air is so polluted that during the 1996 World Cup cricket series, the Australian cricket team refused to play in the city.

Sources of Energy

Earth is a vast storehouse of energy. The fossil fuels beneath its surface, the wind and water on its surface, the plants growing on it, the sunlight falling upon it—these are all sources of energy.

All energy sources can be classified into two basic categories: non-renewable and renewable, depending on the time period over which they can be replenished. The degree of renewability is determined by the human time-scale.

Non-renewable Sources

Fossil fuels are organic remains which have through the process of fossilization, over millions of years, become coal, oil and natural gas. They cannot be renewed over time-scales relevant for one human cycle. They are therefore non-renewable resources. Nuclear fuels are also non-renewable sources of energy. Using the analogy of money in the bank, all these sources of energy are our ‘capital’ which may be extracted at as fast rate as we want, but once they have been used up, they will be gone forever. The earth contains huge stocks of these sources of energy, but they are in fixed quantities and these stocks are being steadily depleted.

Coal is one of the primary sources of energy, accounting for about 67 per cent of the total energy consumption in the country. India is the fourth largest producer of coal in the world and has some of the largest reserves of coal in the world. With the present rate of around 0.8 million tons average daily coal extraction in the country, the reserves are likely to last over a 100 years.

Renewable Sources

Renewable sources of energy are those which have the potential of being continually replenished. Most renewable energy resources are powered directly or indirectly by the energy of the sun, and therefore are likely to last as long as the sun lasts. These include solar radiation, energy from flowing or falling water, and from wind. These resources can however be tapped only at a certain rate—if the extraction rate is higher than the production rate, then the renewable source is no more a renewable source.

Other renewable sources of energy are biomass (food, wood, and animal and crop wastes), and animal and human muscle power.

Biomass—A Renewable Resource

Biomass can be defined as the weight of all the living organisms in a given population, area, volume or other unit being measured. Often it is also considered as the weight of dry matter of living organisms (phytomass of plants and zoomass of animals) at any given time per unit area. Plant biomass provides the primary energy source and acts as the foundation for all life forms. It is an important and major source of food, fodder for livestock, timber for housing and furniture and many other products needed for human existence.

In India, biomass is a major source of energy. Biomass resources too can be exhausted if their rate of use exceeds the rate at which they are replenished.

Another way of classifying energy sources is as 'non-commercial' and 'commercial' energy.

Non-commercial energy includes fuels such as firewood, dung and agricultural wastes which are traditionally gathered and not bought. These are also called traditional fuels. However, when these sources of energy become scarce, often they too have to be bought.

Non-commercial energy has been used by human beings for a long time. We use solar energy for drying grains, clothes, fish and fruits; and the energy of flowing water for grinding grain. Non-commercial or traditional sources of energy also include animal and human muscle power. We use these for transportation, ploughing, threshing, lifting water for irrigation, crushing sugarcane, etc. Unfortunately these are not included in most energy statistics. Nor are the other sources of energy harnessed through traditional means, such as the power of flowing water used by water mills. While these sources of energy continue to be widely used in developing countries, these countries are now becoming increasingly dependent on commercial sources of energy.

Accurate records of the use of non-commercial energy do not exist. Biomass fuels are estimated to have contributed 41 per cent of total inland primary energy supplies in 1998; in India's rural areas, the percentage supplied by biomass (wood, animal dung and agricultural residues) rises to about 95. Whereas the use of dried dung and waste as fuel is widespread in agriculturally prosperous regions, wood is still the principal domestic fuel in poorer and less well-endowed regions. Overall, fuelwood is estimated to provide almost 60 per cent of energy in rural areas and around 35 per cent in urban areas.

Commercial energy, also known as industrial energy, is energy that is bought and sold. By far the most important forms of commercial energy are electricity and refined petroleum products. The primary energy sources such as coal, oil, natural gas, flowing or falling water, and nuclear fuels are converted into secondary energy forms like electricity, which are of greater use and value, and these are sold.

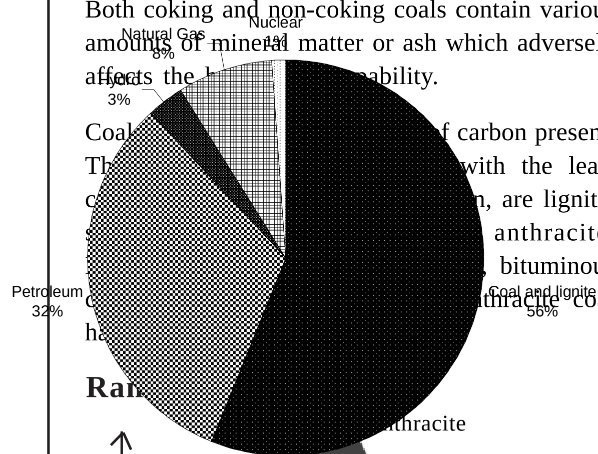
Commercial energy forms the basis of industrial, agricultural, transport and commercial development in the modern world. In industrialized countries, commercial energy is the leading source not only of economic production but also for most household and personal tasks such as drying clothes, shaving, and even for brushing teeth.

The production and consumption of commercial energy from conventional sources—i.e., fossil fuels, large-scale hydroelectric and nuclear sources—is continuing to rise worldwide. However, efforts are also on to harness commercial energy from alternative renewable resources such as solar, geothermal, wind, wave, small-scale hydro and non-traditional biomass.

India: Current Energy Scenario

The energy sector plays a pivotal role in the overall development of any country. India is relatively well endowed with both renewable and exhaustible energy sources. Coal, oil, gas and hydro constitute the main sources of energy in the country. A large amount of traditional energy sources in the form of fuelwood, agricultural waste and animal residue are used in the country. Traditional energy sources account for nearly 40 per cent of the total energy consumption in our country.

Share of Energy Sources in Commercial Energy Consumption (1997/98)



Source: State of the Environment, India, UNEP 2001

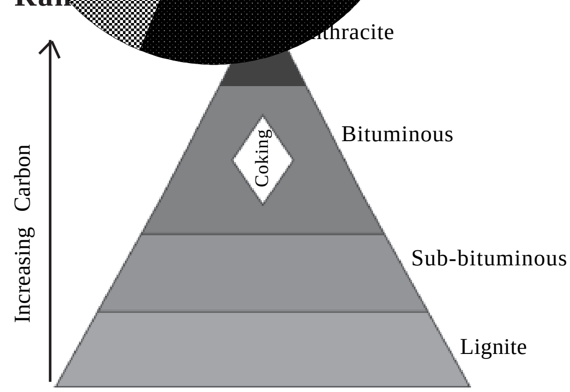
Coals and Coke

Coal consists of a complex range of materials. Coal from one deposit may differ greatly from that of another. These differences are due to varying types of vegetation from which the coal originated; the depths of burial, and the temperatures and pressures at those depths; and the length of time the coal has been forming in the deposit. The varying amount of mineral matter in a coal deposit may also have a significant effect on its properties and classification. In addition to carbon, coals contain hydrogen, oxygen, nitrogen and sulphur. Depending upon its composition, each type of coal burns differently and releases different types of emissions.

Coal is converted to coke by heating coal in the absence of air to drive off the volatile compounds. This process gives hard, porous carbon material which is referred to as coke. These types of coals are used in metallurgical industry. Coals lacking this property are called non-coking and are used in power, railway, fertilizer and other industries. Both coking and non-coking coals contain various amounts of mineral matter or ash which adversely affects the h[illegible]ability.

Coal [illegible] f carbon present. Th[illegible] with the least c[illegible]n, are lignite, s[illegible] anthracite. [illegible], bituminous c[illegible]thracite coal ha[illegible]

Ran[illegible]



Production Trends in Coal, Oil, Gas and Petroleum Products in India					
	Production				Net Imports
	1975/76	1985/86	1995/96	1998/99	1998/99
Coal (million tonnes)	99.7	154.3	273.4	296.5	14.8
Crude oil (million tonnes)	8.4	30.2	35.1	32.7	39.8
Petroleum products (million tonnes)	20.8	39.8	55.1	64.5	17.4
Natural gas (billion cubic metres)	2.4	8.1	22.6	27.4	–

Source: State of the Environment, India, UNEP 2001

Broad trends in the production and consumption of the energy are outlined below:

Production

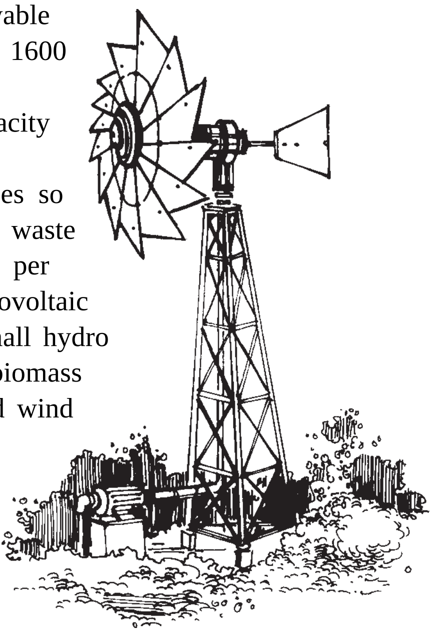
Coal is the major exhaustible energy resource in the country. Although reserves are substantial, Indian coal is primarily non-coking coal of a poor quality, with high ash content (40–50 per cent). It provides approximately 39 per cent of India's total energy requirements and is the source of 60 per cent of commercial energy. Its proven reserves are nearly 68 billion tones. Most of India's coal reserves are in the Gondwana Basin.

Oil accounts for 30 per cent of the nation's commercial energy supply. Of the 26 sedimentary basins, only six have been explored so far. Inspite of a significant growth, domestic production has not matched demand, leading to a constant growth in net imports.

India has substantial reserves of nuclear fuels—the world's largest deposits of thorium (about 363 thousand tonnes) and uranium ore (about 34 thousand tonnes).

Power generation—the generating capacity in India comprises a mix of hydro, coal-based thermal, oil-fired thermal, gas and nuclear. Lately non-conventional energy sources, particularly wind energy have also become important. About 72 per cent of power generation is thermal-based, using predominantly coal. Despite a substantial increase in electricity generation, energy shortages affect all sectors of the Indian economy.

Renewable energy—Solar, wind, biomass, and small hydro are the main sources of renewable energy used for power generation. The potential of renewable energy in the country is estimated at 100000 MW. There has been a steady increase in power generation based on renewable sources. As of December 1999, 1600 MW, representing a little over 1.5 per cent of the total grid capacity was based on renewable sources. Of the 1600 MW of installed generating capacity contributed by renewable sources so far, energy from waste accounts for 0.9 per cent, solar photovoltaic 2.6 per cent, small hydro 13.1 per cent, biomass 16 per cent, and wind power 67.4 per cent. India has the fifth largest wind power capacity in the world.



Apart from supplementing power generation and providing electricity to rural and remote areas, substantial progress has also been achieved in providing energy for a variety of applications in villages, such as pumping water for irrigation, drying farm produce and providing improved cook-stoves and biogas plants.

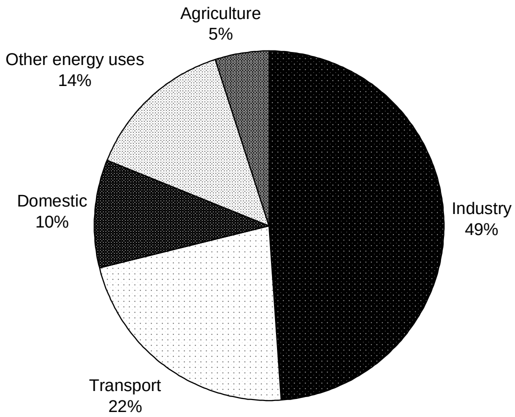
As part of one of the world's largest renewable energy programmes, in India, approximately 3.27 million biogas plants, 3,38,000 biomass based chulhas and 5,90,000 sq.meter solar energy collector area, apart from 5,15000 solar cookers have been installed. About 1450 projects have been approved in areas of renewable energy development that is expected to help generate 1650 MW and help 935 metric tons coal replacement.

Consumption

Energy is consumed by different economic sectors — agriculture, industry, transport, and domestic.

The **industrial sector** is the largest consumer of commercial energy, accounting for about half of the total commercial energy consumption in 1999/2000. Coal and lignite meet over half of industrial commercial energy requirements. The most energy intensive industries are the fertilizers, aluminium, textile, cement, iron and steel, pulp and paper and chlor-alkali.

Sectoral Composition of Commercial Energy Consumption: 1999/2000



Source: TERI Estimates,
http://www.teriin.org/energy/overvw.htm

The **transport sector** is the next biggest consumer, accounting for 22 per cent of total commercial energy consumption.

Commercial energy consumption in the **agricultural sector** has grown significantly with increased mechanization and modernization of agricultural activities, and accounts for around 5 per cent.

The **domestic sector** accounts for 10 per cent of the commercial energy consumption in the country.

The Problems

The commercial energy resources that we currently depend upon are largely non-renewable, making our growing demand for energy, our lifestyles and patterns of energy use, clearly unsustainable.

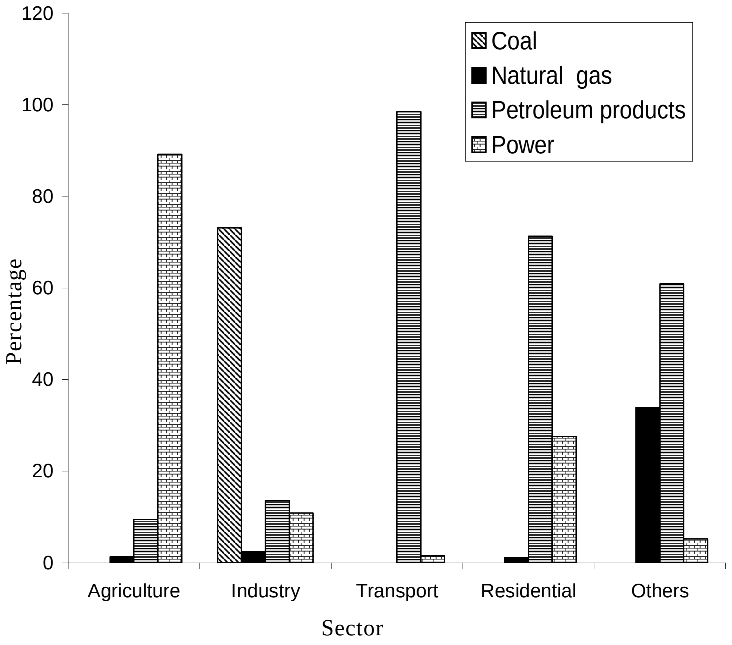
The per capita commercial energy consumption in India is still low when compared to other countries, being less than 4 per cent that of a developed country such as the USA. However we need to look at energy issues holistically and choose a way, which through a mix of policy, institutional, and technological tools, is more sustainable and viable.

We will now look at some of the problems and issues associated with availability and requirement, growing imports, inequitable distribution, inefficient technology, unsustainability and environmental costs.

Energy Shortage

Like most other rapidly developing countries, India suffers from energy shortages. Coal is the primary fuel in power generation in India. Over the last decade, shortages of coal and therefore electricity have steadily worsened. On a countrywide basis, electricity generation is about 10 per cent less than the potential demand. In some regions the situation is much worse. This has led to frequent power breakdowns, voltage fluctuations, and

Sectoral Energy Consumption by Fuel (%):1999/2000



Source: TERI estimates

planned and unplanned power cuts. Many industries have, therefore invested in diesel-driven back-up generators, leading to greater demand for imported oil.

India's demand for oil has been steadily rising. The persistent shortages of coal and power supply is a factor contributing to a more rapid rise in consumption of petroleum products. In agriculture at least 5.5 million diesel pumps are currently in use for pumping irrigation water. The transport sector is a major user of oil. The use of diesel in road and rail transport has increased significantly. Rapid and unconstrained growth of cities, inadequate public transport and rise in income levels have led to a phenomenal growth in the number of privately owned vehicles. This has led to increase in demand for petrol and motor oil. India has met this demand by developing its own oil resources and by imports. The import requirement to meet this growing demand could have a disastrous effect on India's foreign exchange situation and its external debt.

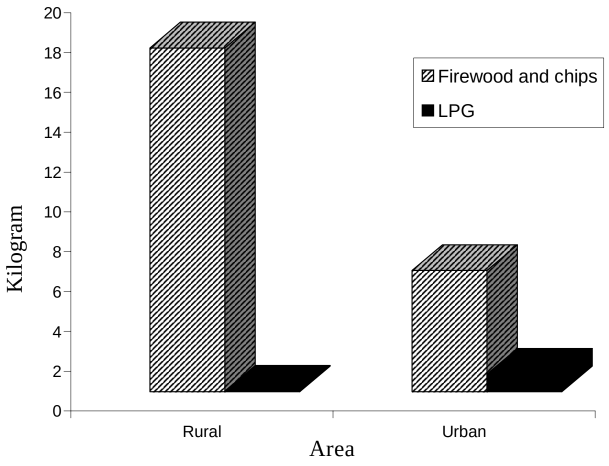
Inequitable Access

The decline in the availability of firewood is driving the landless poor and marginal farmers, who cannot get adequate crop wastes from their small landholdings, to depend on cattle-dung. In many parts of rural India dung and agricultural wastes are increasingly becoming market commodities. This has affected the rural poor. The situation of rural women is worsened when they have to spend longer hours and more energy searching for and gathering fuel. The adoption of domestic biogas plants by many of the larger farmers and cattle owners is also a reason of reduced access of poor farmers to dung which they were earlier free to collect from streets and fields for fuel.

The inequities of access to the various types of fuels are not just between the rich and poor, but between rural and urban areas. The rising demand for fuelwood by the urban poor who cannot afford or access commercial fuels (for example, if they do not possess a ration card, as is often the case with slum and pavement dwellers) has resulted in a sharp increase in fuelwood prices in urban areas. This has led to truck-and wagon-loads of firewood harvested from forests at ever increasing distances, and hence increasing costs, being sent to major cities in the country. In some cases this reduces supplies in rural areas where firewood has traditionally been a noncommercial resource. The urban demand has contributed to the depletion of forest cover not only in areas near urban markets but in distant areas as well. Delhi, for example, receives firewood from as far as Assam, which is nearly 2000 km away.

Government subsidizes some products like kerosene, cooking gas while it taxes others. The price for kerosene is subsidized with a view to protect consumers but the benefit of the subsidy is not directed to the poor in particular. As a result of this, while the relatively cheap kerosene is often used for adulteration in the transport sector, the poor consumers are unable to fulfill their total

Monthly Per Capita Consumption of Selected Fuels in Rural and Urban Areas, 1993/94



Source: State of the Environment, India, UNEP 2001

requirements of kerosene from the ration shop. They have to depend in part on supplies from outside sources where they pay much higher prices.

Inefficiency

Widespread inefficiency in power generation, transmission, management and use intensifies energy shortages. Some industries and power plants use outdated equipment and processes. For example, manufacture of steel in India requires twice as much energy as in an industrialized country. Poor maintenance of equipment and inadequate monitoring procedures also contribute to inefficiency. Some of the factors in different sectors are:

Power sector: More than 20 per cent of the electricity generated in India is lost during transmission and distribution (T and D). These losses occur because of too many transformation stages, poor quality of wires and equipment, friction and heat loss when electricity generated is transmitted to over long distances from the source of generation. In addition, there are non-technical losses because of pilferage, theft and unmetered supply.

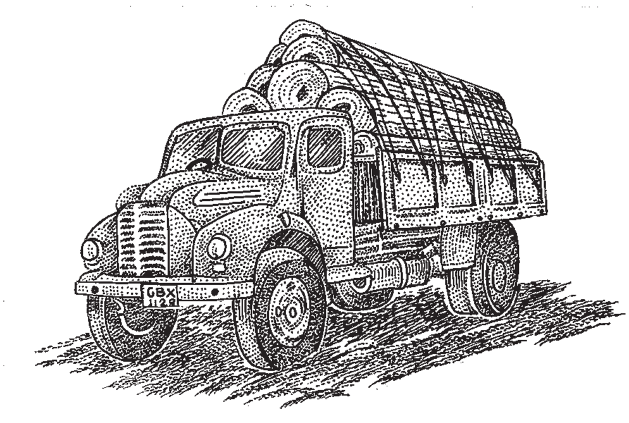
Transport Sector: In the transport sector, both public and private vehicles are, by and large, poorly maintained which adds to their inefficiency. Ensuring fuel efficiency has not been a priority with automobiles manufactures.

Domestic Sector: The combination of using inefficient fuels (fuels that have a low combustion efficiency) in inefficient stoves (that transfer only 10 to 15 per cent of the heat to the pot in which the food is cooked while the rest escapes as waste heat) is negative from the standpoints of energy, health of the cook, and for the environment. Besides, the use of dung-cakes as fuel deprives the soil of organic matter and of nutrients such as nitrogen which this non-commercial source of manure would otherwise provide.

Unsustainability

By definition, the use of nonrenewable energy sources in the long term is not sustainable. Although biomass is a renewable resource, the current pattern of consumption of biomass fuels is also unsustainable. For example, the overharvesting of forests, partly for timber and other demands, and partly to meet the firewood demand in urban areas, is causing deforestation. India currently uses about 227 million tonnes of fuelwood energy per year and this figure is growing with population and economic growth.

The scarcity of fuelwood has increased pressure on other biomass resources such as cattle dung and crop residues. Use of these resources as fuel takes them away from other more appropriate uses as fertilizer and mulch.



Environmental Costs of Energy Use

The use of any of the various conventional energy resources has some adverse environmental consequences at some stage—from its extraction, through processing and transportation to its end use.

Biomass

If biomass is consumed faster than it can regenerate, then biomass denudation (especially deforestation) results, which leads to soil erosion, loss of productivity of soil, disruption of stream flows and loss of habitats.

Biomass, when burnt as fuel also emits carbon-containing materials, namely, carbon monoxide, other hydrocarbons, and suspended particulate matter like soot and ash, thus causing air pollution. The emission of carbon dioxide and methane contributes to the build-up of greenhouse gases that cause atmospheric warming. (*See chapter 'Atmosphere' for more details on Greenhouse Gases*)

Coal

Coal is mined in two ways—underground mining and open cast mining. Both have their specific environmental effects, but both degrade forests and land, pollute water and air, and affect the health of miners and people living near the mines. In open-cast mines, almost complete recovery of coal takes place. Thus they are more efficient. In underground mines, 40 to 60 per cent of the coal has to be left in place to hold up the structure. Occasional roof collapse and explosions in the underground mines kill miners. The enclosed, coaldust-laden atmosphere adversely affects their health.

Under present practices, open cast mines are safer, but they destroy, often permanently, the vegetal cover and soil, and disrupt and pollute the aquifers and streams. Coal dust generated by mining pollutes the air for miles. After coal is mined, it is sometimes washed to remove impurities like clay. This uses and pollutes a lot of water.

The worst environmental problem associated with coal is the air pollution generated when it is burned. Coal produces twice as much carbon dioxide (the main greenhouse gas which leads to global warming) per unit of energy as natural gas and 25 per cent more than oil. It also produces fly ash when burnt. Because of variations in the quality of coals from different sources, as well as differences in the operational design, not all fly ash is the same. The problem becomes worse when the coal is of poor quality. In addition to emissions, the disposal of fly ash is one of the biggest solid waste disposal problems in India. For every megawatt of installed capacity, approximately 0.04 hectare of land is required to pile up the ash eight to ten metres high. A majority of thermal power stations in India are 200 to 210 MW units. So the land each coal based power plant requries just to dump the fly ash is enourmous.

In India over 60 per cent of power generation is coal-based, which produces nearly 80–100 million tonnes of fly ash every year. India stands second only to China in the quantum of fly ash generated. Currently, nearly 90 per cent of fly ash generated is dumped as slurry in ash ponds, which requires huge amounts of water. It also results in creation of wasteland and could also lead to leaching of heavy metals and soluble salts. Leaching from ash ponds to neighbouring fields and water bodies can lead to surface and groundwater pollution.

> **Leaching** is "washing out" of soluble chemicals from soils that are not "bound" to the soil particles. It occurs as excess rain (or flood) waters drain through the soil.

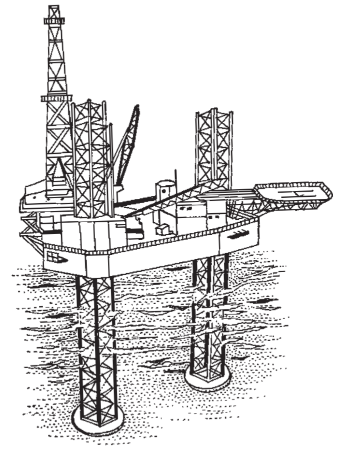
Efforts are on to develop uses for fly ash. It has been commercially used for making bricks, blocks and as an ingredient in cement. It has also been used to fill up old mines. But at present only about 3 per cent of the fly ash generated each year is being put to these uses. Recent research at the University of Calcutta has found that fly ash is an excellent catalyst for treating toxic and nonbiodegradable chemicals in effluents from the pesticide industry.

Oil and Natural Gas

The process of oil and natural gas exploration and extraction is very energy intensive. Both exploratory and commercial drilling, even if done with a lot of care, result in the release of some toxic chemicals and therefore in pollution of water and air. Accidental explosions and occasional leaks occur both during exploration and production.

Today all oceans are contaminated to some degree by oil slicks (thick patches of oil floating on water) and petroleum residues. These come from offshore oil wells, ships (from collisions, leaks and flushing of tanks), and also as run-off from land-based oil facilities and waste oil. This disturbs the oxygen balance of the aquatic ecosystem and kills thousands of creatures. It enters the food chain and disperses in the sediments and soils. In the sea, oil is especially harmful to lifeforms that cannot swim away, such as coral.

The commercial processing of petroleum products produces solid wastes such as salts and greases. After all the refining and processing, the oil is ready as a fuel. It is then used in vehicles and furnaces. When burned, it produces air pollutants such as sulphur dioxide, nitrogen oxide, carbon monoxide, and, carbon dioxide. Another major group of pollutants are the lead compounds from the lead added to petrol to improve its octane rating to prevent 'engine knock'.



Hydroelectricity

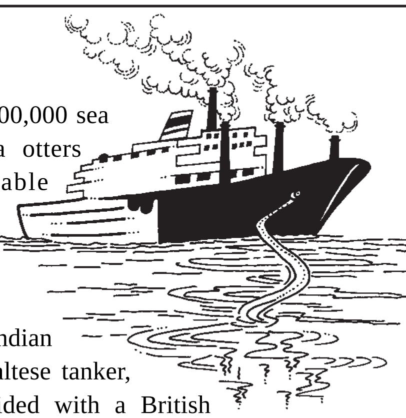
About 28 per cent of electricity produced in India is generated by turbines turned by the force of falling and flowing water. Hydropower generation requires the building of dams behind which water is impounded. Although generation of hydroelectricity does not release any carbon dioxide, the rotting of vegetation caused by the submergence of forests produces methane which is a greenhouse gas.

Another major concern is the threat of earthquakes caused by impounding large volumes of water, which build up tremendous stresses in the earth's crust. The Koyna Dam in India is an example. It was built in 1962 in a stable area known neither for geologic faults nor seismic activity. In 1967, the area was rocked by an earthquake that killed 177

Oil Spills and Accidents

A major fire occurred in Pasarlapudi in Andhra Pradesh in January 1995 when a well was being drilled. The fire raged for 66 days before it was finally put out. Besides the damage it caused to the drilling equipment, and the smoke and other pollutants it added to the air, the fire drove thousands of people from their homes and scorched their crops and trees.

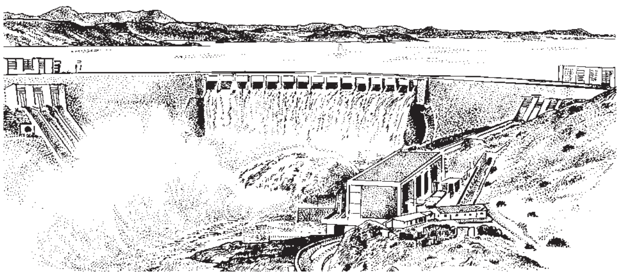
The infamous accident of the oil tanker Exxon Valdez in May 1989 spilled nearly 42 million litres off Alaska's coast, along 1,930 km of coastline killing at least 1,00,000 sea birds, 1,000 sea otters and innumerable seals.



In June 1989 an oil spill threatened the Indian coast when a Maltese tanker, MT Puppy, collided with a British ship, spilling over 5,000 tonnes of oil into the open seas off Mumbai.

people, injured 2300 and rendered thousands homeless. The threat of earthquakes in an area known for its earthquake-proneness is the most contentious issue in the case of the Tehri Dam.

Large dams are a controversial environmental issue in India. Vast tracts of valuable forests, wildlife habitats (both terrestrial and aquatic), biodiversity and agricultural lands are at stake due to submergence. Thousands of people are displaced when a dam needs to be made, and they need to be rehabilitated with fair and equitable resources. Large dams entail severe and often irreparable social and environmental costs, including the displacement of people, submergence of valuable resources and adverse impact on downstream hydrology.



Nuclear Power

In some respects, nuclear power is the 'cleanest' of all energy sources. Its generation and use do not emit any carbon dioxide or other greenhouse gases. Nor does it cause acid rain or urban smog. Yet it is the most controversial source of energy. Exposure to radioactivity is known to cause cancer, genetic defects, and even death.

The basic cause of concern is the possibility of an accident. Although the probability of accidents is low, should one happen, the consequences are serious. Another unsolved problem is the management and disposal of radioactive wastes.

Nuclear power plants use radioactive materials and produce radioactive waste. The power plants have a life of 30 to 40 years, after which they have to be decommissioned. But they contain a lot of radioactive material. It takes from thousands to millions of years for most of these materials to lose their radioactivity. During this time, human beings and other life forms exposed knowingly or unknowingly to nuclear radiation are at risk

Nuclear Disasters

The accident at the Three Mile Island nuclear power plant in USA in March 1979 and the explosion at the Chernobyl power plant in Ukraine (which was then a part of the former USSR) in April 1986, that released large amounts of radioactivity into the atmosphere, have intensified the fear that human errors in operation and maintenance of nuclear power plants could lead to major catastrophes.

Towards Solutions

With Regard to Conventional Energy Resources

For long term sustainable energy planning, it is necessary to move away from dependence on imported oil and towards greater use of renewable energy sources, environmentally low-impact and efficient technologies, and greater self-reliance. A large-scale shift to low-impact technologies based on renewable energy sources is, however, still a distant goal. In the short term, technologies that will reduce the environmental impacts of current energy sources need to be adopted, such as reducing emissions of sulphur and nitrogen oxides, hydrocarbons and particulate matter. For example, experts believe that by improving the petroleum-distillation process to reduce the levels of sulphur and carbon in Indian petrol and diesel, vehicular pollution could be reduced by 30 per cent.

For the next few decades fossil fuels will continue to cater to most of India's and the world's energy needs. The government plans to encourage the use of natural gas to generate electricity. India's natural gas supplies are more plentiful that its oil supplies, gas based electricity plants are cheaper, cleaner and faster to build than coal-based plants.

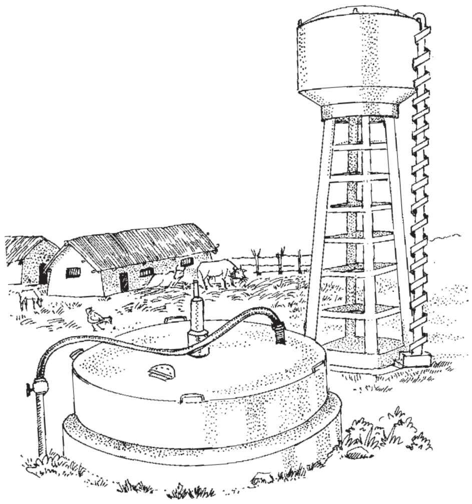
The government is also hoping that opening up the power sector to private companies will boost the development of hydroelectricity. There is also tremendous potential in the country for tapping small streams and canals for building mini and micro hydroelectric plants.

Recognizing the Potential of Biomass

Energy for cooking constitutes a large proportion of India's total energy consumption, and the primary source of energy for cooking for the majority of India's population is firewood. Ninety-five per cent of the rural population and over 60 per cent of the urban poor depend upon non-commercial energy resources—primarily firewood, but also cattle dung and crop residues. Firewood for cooking is one of the basic needs, therefore must be a focus of development efforts. Biomass has great potential as an energy source if its rate of regeneration can at least keep pace with its rate of consumption. This can be done in two ways:

1. By increasing fuelwood production, thereby increasing the existing supply of firewood.

   This would require increase in the productivity of land and tree plantations through careful management and afforestation on degraded lands.



2. By improving the efficiency of firewood use, thereby reducing the existing demand for firewood. This is primarily concerned with increasing the efficiency of the wood-burning devices—primarily the wood stoves or *chulhas*. Improvements in the design of *chulhas* seek to improve the heating process i.e. efficient generation of heat through efficient burning of the wood, efficient transmission of heat to the cooking pot and retention of heat in the *chulha* and minimization of dissipation of heat.

Energy Conservation

Energy conservation means using energy more efficiently and less wastefully. Conservation of energy is an important energy resource because a unit of energy saved is as good as a unit of energy generated. Besides, it is cheaper to save energy than to produce it, and the saved energy becomes available for some other use. In essence, it means "doing more with less".

At the Sectoral Level

A few sector-wise examples of energy conservation are discussed below:

Industry is the largest consumer of commercial energy in India. Therefore this sector can make the greatest contribution to energy conservation by using energy-saving equipment and adopting more efficient and sustainable processes and practices. In industrialized countries, the focus is on production process. Products are being redesigned to use less material or substitute new materials which require less energy in their manufacture than traditional material. Efficiencies are being brought about in processes.

For efficient energy generation and distribution, cogeneration units could be installed in factories and thermal power plants. Cogeneration means production of two useful forms of energy from the same process. For example, while producing sugar, crushed sugarcane stalk, or bagasse is also produced as waste. This waste product is used in 'cogeneration', i.e. it is burnt to produce steam and electricity which is utilized by the sugar factories. The introduction of high pressure boilers and turbogenerators could produce more power from the same quantity of bagasse. This would not only meet the needs of the sugar factories but could also supply India's electricity needs.

Transport is the second largest consumer of energy after industry. While the entire transport system needs major restructuring to make it more efficient operationally as well as in its use of energy, the focus here is primarily on the urban commuter transport system.

Vehicular traffic in cities and towns is the major source of air pollution, noise pollution and road congestion. There is need to develop energy-efficient motorized vehicles and systems for their proper maintenance, to ensure fuel efficiency and less pollution. Improvements in public transportation would reduce dependence on private vehicles and improve the quality of transportation services available to the average citizen, besides reducing pollution and saving energy and money.

Power—It is the responsibility of power companies and the state electricity boards to supply the amount of electricity required by their customers. A concept that has great value especially for the power sector is **demand side management (DSM).** In this, the power companies, rather than trying to meet the current shortages and also the rapidly increasing demand for more power, helps their customers to reduce the demand.

At Individual Level

Energy can be saved basically in two ways:

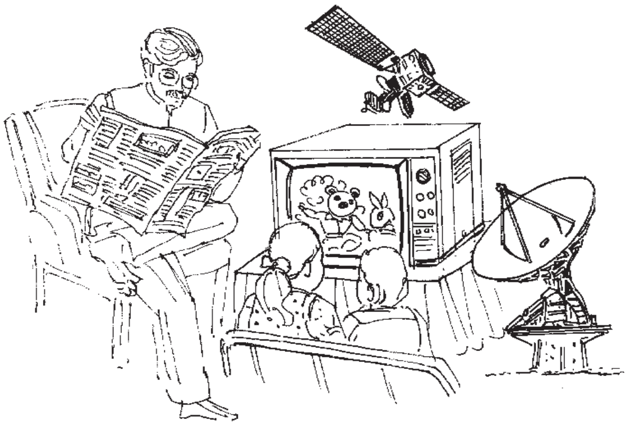
1. By using energy-efficient equipment

Efficiency means getting the greatest possible amount of output with the least amount of inputs—resources, effort and cost. Through efficiency, we can use less energy to do the same amount of work, and in some cases, do even more work. For example, using a pressure cooker, an energy-efficient model of a refrigerator or a *chulha*, or a compact fluorescent light bulb.

> ### Reducing the Demand
>
> The Ahmedabad Electricity Company (AEC) has initiated a pilot project in which energy-efficient water pumps have been installed in multistoreyed apartment buildings and more efficient motors in various industries. Several other areas have also been identified which include replacement of conventional lightning with compact fluorescent lights (CFLs) and energy audit for industry. AEC estimates that the potential saving through DSM over a five-year period will be 25 MW or nearly Rs.1 crore in construction cost of new power generating capacity.

Energy-efficient models or products may cost more initially than the conventional ones, but they save money in the long run by having a lower life-cycle cost, i.e., initial cost plus lifetime operating costs. And the saving in energy is not a one-time saving because an energy-efficient device goes on saving energy throughout its life. (*See box: Energy-efficient Products*). Energy conservation is often the cheapest, and perhaps the largest source of energy available to us.

According to one estimate, if just 20 per cent of the more than 30 crore conventional light bulbs in use in India in 1990, were replaced with compact



Energy-efficient Products

"Energy-efficient" products such as fluorescent light bulbs provide the same amount of light as the less efficient incandescent bulbs, but they use less energy in doing so. High efficiency fluorescent light bulbs last about 10 times longer than normal light bulbs. They use one quarter as much electricity to deliver the same amount of light. A comparison between a fluorescent light bulb and an incandescent bulb shows that a 75 W filament bulb consumes 75 units for running 100 hours, while a 15 W fluorescent light bulb which gives the same amount of light as a 75 W bulb does, consumes only 15 units. Fluorescent light bulbs contain Krypton and Argon gases which are safe and do not harm the environment.

Another example of an energy-efficient product is an improved chulha. The thermal efficiency of an improved chulha is 20-35 per cent, as compared to that of a traditional chulha, which is only 10 per cent.

Many of us are not aware about a range of energy-efficient products available in the market, and even those who are aware, may not adopt newer technologies. One of the reasons for this could be that energy-efficient products like fluorescent light bulbs cost more initially than conventional products like incandescent bulbs. However, use of energy-efficient products helps save money in the long run and saves energy throughout its lifetime. Use of energy-efficient products like fluorescent light bulbs is one way of saving energy and money in the long run.

fluorescent light bulbs, the country's power requirement would be substantially reduced. India could avoid building 8,000 MW of new power capacity. India could also halve its firewood requirements just by doubling the fuel efficiency of woodstoves.

2. By changing energy-wasting habits and lifestyles

- Switching off a light when it is not needed
- Walking or riding a bicycle instead of using a two-wheeler or a car for a short trip
- Regularly defrosting the refrigerator
- Turning the tap off while brushing one's teeth— not only does that save water, but also the energy used for pumping the water.

Such changes in habits do not cost any money.

Equally important is cutting down wasteful consumption in our day-to-day life. All commodities require the input of energy at all stages of production, packaging and transportation. Take a shirt, for example. The production of the fibre (whether natural or synthetic), the yarn, the fabric and the shirt all require input of energy. So do the plastic bag and the carton in which it is packed. Energy is used to transport all the raw materials as well as the finished products. The shirt therefore has a certain amount of energy embodied in it. So by not buying the shirt that one does not really need, one will be saving more than just the energy spent on a trip to the store.

Adoption of a combination of the two approaches, by individuals in their personal lives and by society as a whole, in every sector of the economy, is required for meeting our energy requirements affordably and with tolerably low environmental impact.

The Future Scenario

To improve our energy future, energy supplies have to be increased sustainably and energy demand reduced through efficient use. There is a need to shift towards renewable energy resources that are more equitably distributed, more affordable and less environmentally destructive than fossil fuels. At the same time, though there is a rapid move towards renewable energy sources, the dependency on fossil fuel will remain for several decades to come. Therefore there is need to reduce the environmental impacts of current energy sources by finding ways of burning them more cleanly and efficiently.

The energy policies of the government aim to ensure adequate energy supplies at minimum possible costs, achieving self-sufficiency in energy supplies and protecting the environment from adverse impact due to utilization of energy resources.

At the national level the following strategies need to be considered:

- To improve performance of production systems through improved energy efficiency.
- To recognize that while India's per capita consumption of energy is low, energy efficiencies are also low.
- More energy-efficient technologies and advanced fuel systems with near-zero emissions need to be promoted.
- To promote clean technologies, and reducing energy demand are likely to minimize local pollution and even reduce carbon emissions.
- Experiences gained over the last two decades in India in the area of renewables—wind power, small hydro power systems, biomass-fired plants and solar photovoltaic systems—need to be upscaled to respond to emerging needs of sustainable development.

Solar Panel