ENERGY IS LIFE

LET US EXPLORE ENERGY

A Resource Book for Primary Schools

ENERGY IS LIFE

A Resource Book on Sustainable Energy Use

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INTRODUCTION

As we usher in the 21st Century, humankind faces many challenges that threaten our very survival. High on the list of these are shortages in **energy** and **water supplies**. We are now realizing that this poises a threat to the survival of humankind and all other forms of life on this planet.

Today‘s realisation of the key importance of energy and water to our lives comes at a time when, for example, biomass that provides the largest energy source to about two thirds of the world‘s population, and watersheds from the world‘s various water sourees, have been recklessly cleared without replacement. This has led to unprecedented fuelwood shortages in many parts of the world, drying up of water sourees, total loss of vegetation cover with same areas turning into deserts, and an increase in global temperatures due to the lack of tree cover. This trend needs to be halted and, where possible, reversed.

While the shortage of water has been realised as a serious threat to the world community for over 20 years now, it is just of recent that energy shortages and issues of how we can efficiently use our energy sources have started emerging. In some areas, fuelwood shortages have forced people to use cow dung as a source of heat energy or to eat one meal a day. In Uganda alone, 93% of the country‘s energy needs are met through biomass products. If biom ass users continue to harvest biomass products at the rate at which they are doing today, without putting in place measures to increase fuelwood production while decreasing the rate at which they use it, Uganda could easily find itself in a serious fuelwood crisis.

The MoEMD, therefore, through its Energy Advisory Project, is launehing this Resource Book, wh ich is linked to the current energy topics in the Primary School Curriculum, to popularise the study of energy as a discipline in Ugandan schools. The overall goal of this Resource Book is to build interest in school communities and other stakeholders, which will evolve into a new culture of producing biomass products on their own land. The book is also intended to popularise and promote technologies that can reduce the rate at which biomass products are being used.

This Resource Book, with the accompanying Teacher‘s Guide and Energy Pupil‘s Workbook, have been designed to give both teachers, students, communities and other sustainable energy use promoters adequate knowledge and hands-on practical skills on improved energy use and conservation. This Resource Book does so by addressing energy conservation related problems, and identifying practical solutions to the energy crisis in Uganda today.

The Resource Book is divided into six chapters:

Chapter One:	Understanding Energy
Chapter Two:	Types and Forms of Energy
Chapter Three:	Sources of Energy
Chapter Four:	The Production and Efficient Use of Energy
Chapter Five:	Energy Conservation Technologies
Chapter Six:	Energy and the Environment

We hope the users will find this Resource Book very enriching.

CHAPTER 1

UNDERSTANDING ENERGY

Objectives:
- *To explain what energy is.*
- *To explain how energy is important to people and other living things*.

1.1 What is Energy?

Energy is the ability to da wark or to get things done. In order for us to remain alive we need energy in our bodies. When we have energy, we have the strength to eat, drink, keep warm, build a house, grow crops and even rest when we are tired. In other words, we use energy to do everything that we do; without energy we cannat live. Even the crops we grow for food need energy in order to grow. The animals we keep such as cows and goats need energy to grow, eat and give us milk and meat.

1.2 How Often Do We Think About Energy?

Although energy is such an important part of our lives, many of us often forget to think about its importance. Each time we carry out any activity, we use energy in one form ar the other.

For example, when we cook food at home with our mother, we use firewoad (Fig. 1.a). The fire that cooks our food is a form of energy

Fig. 1.a: Cooking food on an open stove

Many of us enjoy eating our favourite food, as we see in Fig. 1.b. When we are eating, we never think abaut it, but we are using energy to eat. The kind of energy we use when we are eating is called chemical energy. Chemical energy is got from the food that we eat. As we chew the food, the chemical energy turns into mechanical energy; our teeth are used as ‚machines‘ to crush the food and make it soft enough to swallow.

The change of energy from one form to another form shall be discussed in more detail in Chapter Two.

Fig. 1.b: A family eating food

The sound of our teacher‘s voice in class is a form of energy; it is called sound energy. Fig. 1.c. We use our ears to listen to our teacher‘s message; listening involves both sound and mechanical energy

Fig. 1. c: Students listening to their teacher in class

When we sit for examinations in dass, as in Fig. 1.d, we use energy to think of the right answers. We also use energy to write the correct answers on our papers. Our teacher also uses energy to supervise us as we do the examination.

Fig. 1.d: Pupils sitting for examinations and a teacher supervising them

Playing with our friends takes a lot of our energy, but is a lot of fun. Imagine 1000 school children playing in the school compound at break time; how much energy are they using all together? They are sweating, pushing each other, laughing - all this takes up energy. For example, the children playing in Fig. 1.e below are using both chemical and mechanical energy.

Fig. 1. e: Girls skipping a rope

When we do homework at home or at a boarding school like in Fig. 1.f, we need light. Without light, be it an electric bulb, paraffin lamp or candle, we cannot see what we are reading in the dark. Light is another form of energy.

Fig. 1.f: Reading with a light

As we can see from the above examples, to carry out any of the above activities, we use energy. It is therefore important for us to find out more about how our bodies get energy. How is this energy made? How can we make sure that we have enough energy all the time to remain alive and do all the good things that make our lives better? Let us explore more about energy.

1.3 Energy and Our Daily Life

In some parts of Uganda, especially in Kumi and Soroti districts, many farmers use oxen to dig up their crop fields, as we see in Fig. 1.g. These oxen pull ploughs which dig up the soil. Instead of using people to dig with hand hoes, as is illustrated in Fig. 1.h, the oxen dig the soil for the people. The people save their energy while the oxen use a lot of energy. These oxen need to eat a lot of good grass to have the energy to dig large areas for planting big gardens of maize, sesame (simsim), cotton and millet.

Fig. 1.g: Ploughing land using oxen

Fig. 1.h: Preparing a garden using hand hoes

However, instead of using oxen or hands to dig, some people in Uganda use a tractor to dig. This machine is illustrated in Fig. 1.i below. A tractor uses a lot of energy in the form of petrol or diesel, but it can dig large areas of land quickly.

Fig. 1.i: Ploughing land with a tractor

In the past in many parts of Uganda, people used to carry sick people on a stretch er made of poles and ropes, as in Fig. 1.j. They would travellong distances, sometimes even more than 20 kilometres to carry their sick to hospital. The people carrying the patient would use a lot of energy and sweat a lot.

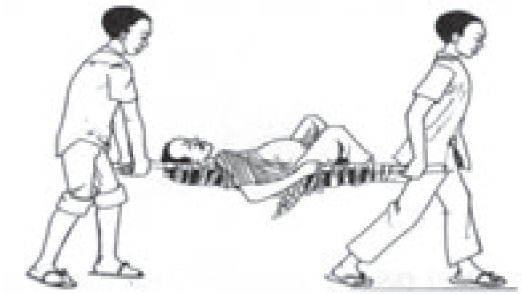


Fig. 1.j: A patient being transported on a stretcher

Nowadays however, you can hire a car to take a patient to hospital, as we see in Fig. 1.k. A car uses tuel, such as petrol or diesel, for energy. A car moves very fast and can save our patients trom dying on the wav to hospital.

Fig. 1.k: A patient rushed to hospital in a car

In Kampala , Mbarara, Jinja, and other big towns in Uganda, there are big factories that make the products we use in our homes everyday (Fig. 1.l). Some factories make sugar, such as Kakira, Lugazi and Kinyara Sugar Factories, which gives us chemical energy. Other factories make soap, such as Mukwano Soap Factory in Kampala. Some factories make matchboxes, which give us light energy. Others make pencils, pens and books, which we use in class. Most of these factories use electricity. Electricity is another form of energy that makes work very easy. It can move very big machines which even 100 people cannot lift.

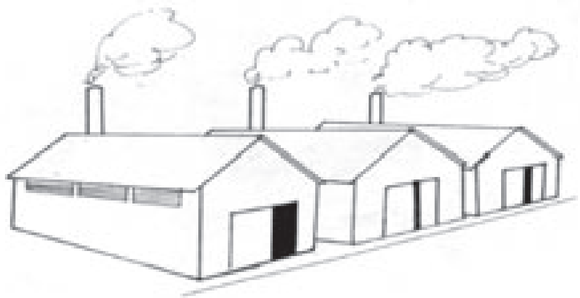


Fig. 1.l: A big factory complex

In our villages there are same smaller factories that help us to make work easier. In the past, most people used to grind maize and millet for food using the traditional grinding stone, as in Fig. 1.m. Imagine how much energy and time you would use if you had to grind millet to feed 400 students in a school. This is hard work and would take a lot of energy.

Fig. 1.m: A woman using a traditional millet grinding stone

Nowadays, many yillages use maize mills to grind maize into flour. These maize mills, like one illustrated in Fig. 1.n, use energy trom diesel or electricity. They make work much easier and faster.

Fig. 1.n: A small maize mill

From the examples above, we have learnt about different forms of energy, and how we use these torms of energy in our daily lives. Some of these torms of energy help to make our activities more easy to do. Now let us see how other living things also get and use energy.

1.4 Energy for Plants and Animals

It is not only human beings who need energy. Plants and animals need energy too, as we shall see in more detail in Chapter Three. Plants receive energy from the sun to make their food and grow, as you can see below in Fig.1.o.

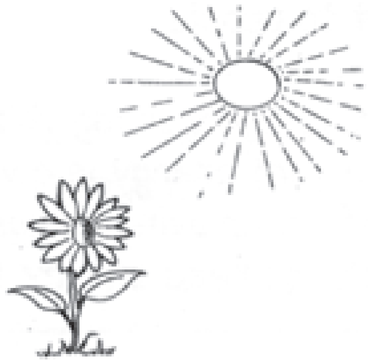


Fig. 1.o: Plants need energy from the sun to make their own food and grow

Animals need energy to eat, grow and reproduce. Wild animals need energy to survive. For example, a lion needs energy to get its food. Lions eat smaller animals such as antelopes, which also need a lot of energy to escape from the hungry lions, as we see in Fig. 1.p.

Fig. 1.p: A lion chasing an antelope for food

Fish need energy to swim and catch food (Fig. 1.q). They also use energy to move about in water and to escape from their enemies.

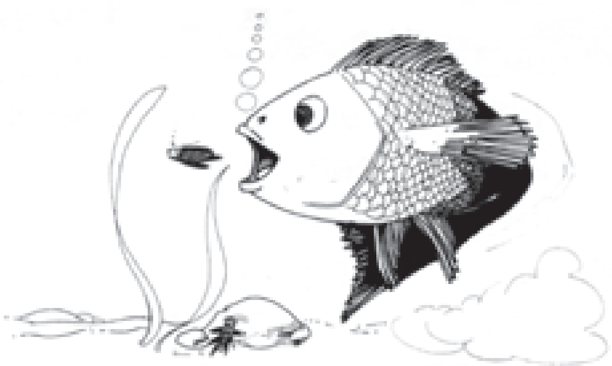


Fig. 1.q: A fish chasing its food

Summary of “Understanding Energy”

You have so far been introduced to the following:
1. The definition of energy
2. Some forms of energy
3. How energy is important to people
4. How energy is important to other living things

We can therefore conclude that energy is a very important component of our lives and the lives of other living things:

All living things need **energy** to **survive**!

In the next chapter, we are going to explore the different types of energy, and the forms in which we get and use energy.

CHAPTER 2

TYPES AND FORMS OF ENERGY

Objectives:
- *To explain the two types of energy.*
- *To explain the various forms of energy.*

2.1 Types of Energy

There are two types of energy, namely **working energy** (or **kinetic energy**), and **stored energy** (or **potential energy**). Let us look at each one of these types of energy in more detail.

a) Working Energy or Kinetic Energy

Everything that moves has working or kinetic energy. A moving vehicle has such energy. A cow that is moving about grazing has kinetic type of energy. A dog chasing a hare and the hare running away from the dog (Fig. 2.a), both have kinetic energy.

Fig. 2.a: A dog chasing a hare

b) Stored Energy or Potential Energy

It is not only moving things that have energy. Even things that are not moving have energy. It is a different type of energy called potential energy. It is stored energy. A rock lying on top of a hill has potential energy. When pushed, the potential energy turns into kinetic energy as the rock rolls down the hill; while the rock is moving it has kinetic energy (Fig. 2.b). When it rests in the valley again, it has potential energy. The bigger the rock and the steeper the hill on which the stone is rolling, the greater the energy that rock has. If it hits you as it is rolling down the hill, you can be injured badly.

Fig. 2.b: A man running away from a rock rolling down a hill

Likewise, a glass placed on a table has potential energy. If somebody shakes the table, the glass gathers kinetic energy as it falls. A brick resting on a wall has potential energy. If a builder pushes it by mistake, the potential energy in the brick is converted to kinetic energy as the brick falls to the floor. Potential energy can therefore be seen as ‚resting energy'. When this energy is converted into motion, it then becomes ‚moving energy' or kinetic energy.

2.2 Forms of Energy

There are several forms of energy; we shall look at eight forms of energy, namely:

- Light energy
- Electrical energy
- Sound energy
- Nuclear energy
- Heat energy
- Chemical energy
- Mechanical energy
- Magnetic energy

Although each form of energy is different from the other, they can be transformed. When one form of energy changes to another form of energy, we say an **energy transformation** has taken place. Energy does not ‚disappear' or die out; it only changes from one form to another. There are many examples of energy transformations, such as these below:

- In green plants, light energy from the sun is transformed to chemical energy, which is stored food
- In a dry cell, chemical energy is transformed to electrical energy as the cell works
- In an electric bulb, electrical energy is transformed to heat and light energy when the bulb is switched on
- In a generator and dynamo, mechanical energy is transformed to electrical energy
- In a motor, electrical energy is transformed to kinetic energy
- A receiver in a loudspeaker transforms electrical energy to sound energy
- When we rub our hands together, chemical energy is transformed to heat energy
- The muscles in our bodies transform chemical energy in the food we eat to heat energy during respiration, this is later transformed to kinetic energy when we do work

Let us now leam about each of the eight forms of energy that we listed above.

2.2.1 Light Energy

During the daytime in Uganda, we have sunlight and can see very easily. We can play games (Fig. 2.c) or dig in the garden very easily. Even when there are dark clouds during the rainy season, there is still enough light for us to see.

Fig. 2.c: During the day, we use light from the sun to see as we play

This natural light during the day comes from the sun. As we shall see in Chapter Three, this light energy from the sun is the most important form of energy for people, and all other living things.

At night, we get ‚light‘ trom the moon. This is actually light that is reflected from the sun, the moon itselt does not give off light energy. We can play outside or sit under the moon and listen to our grandparents tell us stories, as we see in Fig. 2.d. It is wonderful to use such natural light, because it is plentiful and free.

Fig. 2.d: Children listening to their grandfather tell a story under the full moon

However, some nights are dark and when we are inside the house, we need to use another source of light. We can use a lantern, a candle or a lamp (Fig. 2.e).

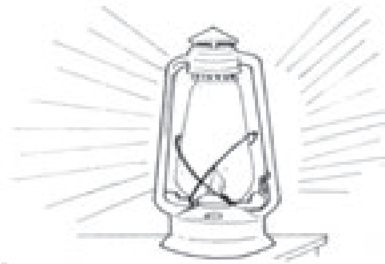


Fig. 2.e: A lamp being used to give light when it is dark

When we light a lamp or an open fire, heat is produced as weil as light. These two forms of energy (heat and light) usually go together. You can see because there is light. Light is therefore a form of energy that enables us to see more clearly. The sun produces a lot of light that come in the form of rays. However, the sun‘s rays also give off heat; if you sit under the sun for a few minutes, you can get very hot. In fact, the sun releases so much heat that you can even use it to start up a fire. If you hold a magnifying glass or a piece of glass (such as a broken bottle) in such a way that the sunlight is weil focused on a piece of dry paper, the paper can catch fire, as you can see below in Fig. 2.f.

Fig. 2.f: Children starting a fire using a piece of broken bottle

2.2.2 Heat Energy

When you walk under the sun or stand near a fire, you will feel hot. You may even sweat. This means the sun or the fire is giving out energy in the form of heat. When we say something is hot, we mean it is giving out heat energy.

The steam given off by boiling water can also produce heat energy. For example, steam can spin turbines, which turn a generator to make electricity.

2.2.3 Chemical Energy

The food that we eat gives us energy (Fig. 2.g). The food is broken down in our digestive system to give us chemical energy. The food we eat is also broken down to produce heat energy as well, which helps to keep us warm. If we do not eat, we will not have chemical or heat energy.

Fig. 2.g: Most of the energy we have comes from the food we eat

When you eat well, you grow up healthy and full of energy. It is important that we eat different foods that provide different nutrients, like proteins from milk and eggs, vitamins from vegetables and fruits, carbohydrates from margarine and rice, and so on. If we eat all the necessary foods in the right amount, then we will have a „balanced diet“, which is very important in releasing energy in our bodies (Fig. 2.h). Without this energy we could easily fall sick, or even die. To live and do any activity, we need energy.

Fig. 2.h: A family eating having a meal with a balanced diet

When you switch on a torch, light comes on. A torch can help to light up a dark room or a cave (Fig. 2.1). The batteries used in a torch have chemical energy stored within them. When the torch is turned on, a chemical reaction takes place in the batteries, which turns the chemical energy into electric energy. It is this electric energy that lights up the bulb of the torch.

Fig. 2.i: Children using a torch to explore a dark cave

Chemical energy can only be released when a chemical reaction takes place. Our bodies run on chemical energy. We use chemical energy every day when we walk, run, play or even laugh (Fig. 2.j):

Fig. 2.j: Chi/dren laughing at their friend because he is not properly dressed

2.2.4 Mechanical Energy

Mechanical energy is the energy that makes things move. It is the energy of motion. Machines have many parts, such as the gears in Fig. 2.k, which can move with mechanical energy.

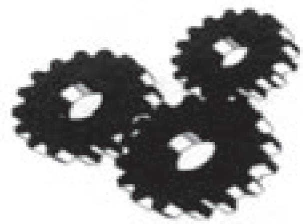


Fig. 2.k: Moving parts of a machine

When we ride a bicycle, we use energy from our bodies to turn the pedals (Fig. 2.l). The pedals force the wheels of the bicycle to turn, using mechanical energy. This energy makes it possible for the bicycle to move.

Fig. 2.l: A child riding a bicycle

2.2.5 Electrical Energy

Electrical energy is also called electricity. This form of energy is used for many things. For example, it is used in factories to make machines work, it is used in schools to light up the rooms when it is dark, it also is used at home to watch television and iron our clothes. You cannot see electricity, but you can feel or see what it does.

Electricity can be produced in many ways; for example, using the sun‘s rays, using the action of falling water, using batteries in a torch, and using petrol in a generator, to name but a few.

In the case of the action of falling water, the force with which the water falls is very strong, as we see below in Fig. 2.m. This huge force spins a machine called a turbine, which in turn spins another machine called a generator to produce electricity, or in particular, hydroelectricity. All this takes place at a hydroelectric power dam.

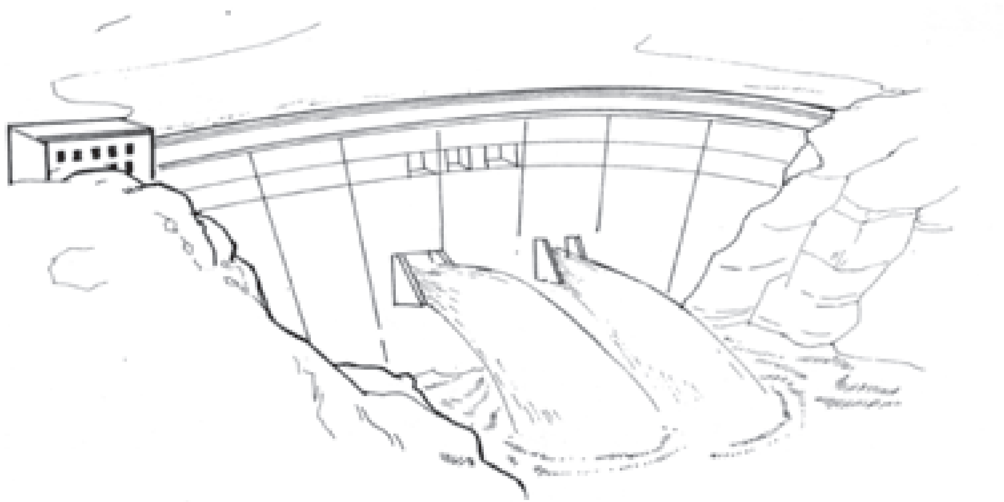


Fig. 2.m: Hydroelectric power dam

Electricity can also be made by a bicycle dynamo. When you ride a bicycle at night, you can use the headlamp to see the road. In order for the headlight to work, we push the dynamo of the bicycle against the back tyre. As we continue to ride the bicycle, the head of the dynamo rubs against the moving tyre, and also starts to move very quickly. This causes electrical energy to run from the dynamo, through the wire, to the bulb in the headlamp; the bulb glows and the headlamp comes on.

2.2.6 Sound Energy

When a machine is started, it makes noise or produces sound. If you touch some part of that machine, you will feel vibrations, or ‚movements‘. When these vibrations come regularly, they make sound, which is a form of energy. If you hit a drum, it will also produce sound. If you put a coin on the drum, and you hit it again, the object will move or ‚jump‘ because of the vibrations coming from the drum‘s skin.

Many of our traditional dances in Uganda use drums to produce good music. It is fun to see a traditional drummer play the drum, as is Fig. 2.n below. Young people these days enjoy music from radios and cassette players, and some people even walk with them so that they can enjoy the music as they are walking (Fig. 2.o).

Fig. 2.n: A traditional drummer

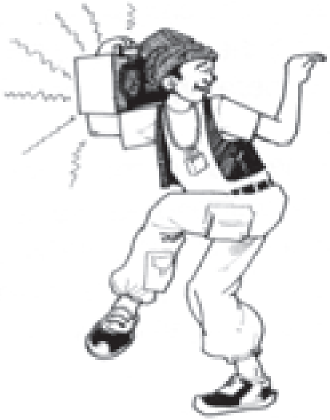


Fig. 2.o: A boy enjoying music trom a radio

2.2.7 Nuclear Energy

To produce nuclear energy, you need an element called uranium. Uranium is a metallic element found underground in some parts of the world, and can be recovered in rocks. We shall discuss nuclear energy in detail in Chapter Three, where we look at uranium as a source of energy.

2.2.8 Magnetic Energy

Magnetic energy is best illustrated using a magnet, or a magnetic bar. Every magnet has two ends; the south pole (5) and the north pole (N). These two ends carry magnetic fields that oppose each other. Two of the same poles will repel, but if the poles are different or opposite, they will attract one another.

In Fig. 2.p below, both pairs of magnets will cling to each other because the north poles (N) and south poles (8) will attract each other. The energy produced between the two poles is called magnetic energy.

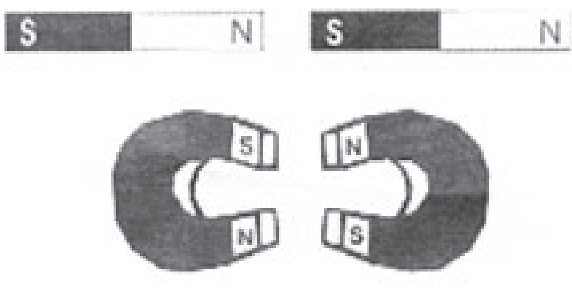


Fig. 2.p: Unlike poles attract causing magnetic energy

Using this same magnetic field, a magnetic bar can cause the movement of certain metallic objects. For example, if you put a razor blade on the table, and you put a magnetic bar just above it, the razor will move and stick onto the magnetic bar, as you can see in Fig. 2.q. Once again, it is magnetic energy that causes the razor blade and the magnetic bar to come together.

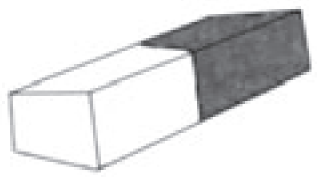


Fig. 2.q: Magnetic energy causes a magnet to easily lift a razor blade

Summary of „Types and Forms of Energy“

In this Chapter we have covered the following:

1. The two types of energy: kinetic energy and potential energy
2. The eight forms of energy:
    - Light energy
    - Heat energy
    - Electrical energy
    - Chemical energy
    - Sound energy
    - Mechanical energy
    - Nuclear energy
    - Magnetic energy
3. One type or form of energy can change to another

Energy does not disappear or get exhausted; it simply changes its type or form.

Every **type** and **form of energy** is useful to people and other living things!

In the next chapter, we shall study in detail the various sources of energy, where they can be found, and their importance to living things.

CHAPTER 3

SOURCES OF ENERGY

Objectives:
- *To introduce the major sources of energy.*
- *To explain the difference between renewable and non-renewable energy sources.*

3.1 Introduction

Since energy is very important in our lives, it is necessary to explore where it comes from. Where does energy come from? Does it come from one source or many sourees? Can an energy source get exhausted? Let us examine these questions.

Energy sources can be divided into two categories, namely **renewable sources of energy**, and **non-renewable sources of energy**.

What is a Renewable Source of Energy?
When we say that an energy source is **renewable**, we mean that we can use it over and over again without it running out. A good example of a renewable energy source is the sun. The sun gives us light and heat every day. Wind also blows every day, and can turn wind-mills. Trees give us firewood, which we use for cooking our food; if we keep planting many trees, we cannot run out of firewood. Crops keep.growing year by year to give us food, from which we get chemical energy for our bodies.

What is a Non-Renewable Source of Energy?
When we say an energy source is **non-renewable**, we mean such a source takes thousands of years to form, and when it runs out, it cannot be replaced or recreated in a short time. Some examples of non-renewable energy sources are crude oil, coal, natural gas and uranium.

Let us look at these two categories of energy sources in more detail.

3.2 Renewable Energy Sources

3.2.1 Energy from the Sun (or Solar Energy)

Most of the energy used on our planet Earth comes form the sun. Without energy from the sun, no animals, human beings or plants would survive on Earth. They would all die. The sun is therefore the most important source of energy to us. Energy from the sun is also called **solar energy**; the word solar comes from sol, which means sun.

The sun is a giant ball many times bigger than the planet Earth. It produces a lot of heat from its interior during a process called nuclear fusion. The energy produced is converted into heat and rays of light, called radiant energy. The radiant energy travels in the form of rays, and travels in all directions. Some of it reaches the Earth (Fig. 3.a).

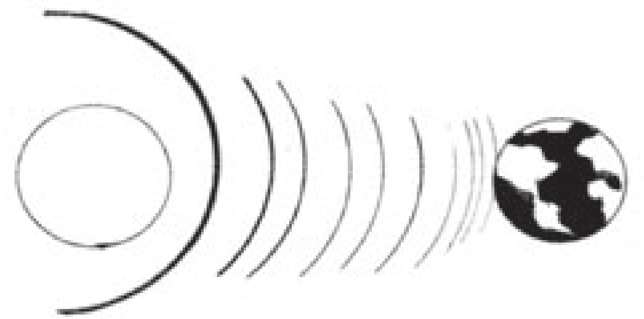


Fig. 3.a: Some of the sun‘s rays reach planet Earth

The sun radiates more energy in one second than the world has used since it was created. However, only a very small portion of the sun‘s energy radiated into space strikes the Earth, that is, one part in two billion. This amount of energy is still a lot to us on Earth. Try standing out in the hot sun for just 10 minutes; how hot do you feel? Imagine if all the heat from the sun went on your body. You would probably be burnt like charcoal in a fraction of a second. That is how intense the energy from the sun is.

When the rays from the sun reach Earth, some hit the clouds and ‚bounce back‘ or are ‚reflected‘ into space, as is illustrated in Fig. 3.b. Some rays reach the earth surface and are absorbed by soil, plants, and other things in our surroundings.

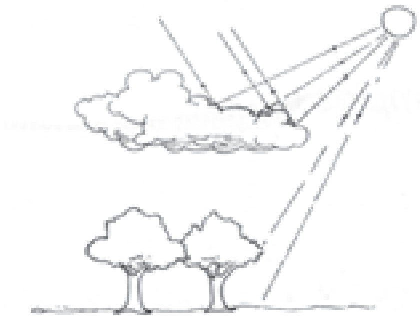


Fig. 3.b: A small portion of the sun‘s rays is absorbed by earth, the rest is sent back to outer space

The earth however absorbs most of the sun (solar) energy that reaches it and turns it into, heat. This heat warms the earth and the air around it - the atmosphere. This is how the earth keeps warm. All living things on Earth, human beings, animals and plants keep warm using this heat energy. Without the sun, we could not live on the Earth. It would be too cold. Everything would freeze and die.

- **The Importance of Solar Energy to Plants**

As already mentioned above, people, plants and animals cannot live without the sun‘s energy. Plants in particular, absorb radiant energy from the sun to make food that they feed on in order to grow. Most plants contain a chemical called chlorophyll. Chlorophyll is the green colouring that makes the plants‘ leaves green. The chlorophyll absorbs sunlight and uses this sun energy to process sugars or food for the plant. This process of making plant food is called photosynthesis; this comes from the word *photo*, which means light. Plants therefore take in solar energy, and store it in their leaves and roots as chemical energy. This is what gives the plants energy to grow and multiply.

- **The Importance of Solar Energy to Animals**

Animals that live on land, and even those that live in water such as fish, obtain the energy to grow and remain alive from the sun in the same way. Same animals feed on plants, and get the energy that these plants made from the sun‘s rays. The animals use this energy to eat, grow, and produce young ones. When we eat animals‘ meat or drink their milk, we get energy for our bodies. We then use this energy to do work, or we store it to use at a later stage.

- **The Importance of Solar Energy to People**

When we eat plants and their products such as mangoes, pineapples, maize, cassava and rice (Fig. 3.c), the energy from the plants is transferred to our bodies.

Fig. 3. c: Examples of plant products that give us energy

This stored energy from plant foods that we eat is mixed with the oxygen we breathe. A chemical reaction takes place in our bodies in a process called oxidation, ar more specifically, respiration. It produces the energy for us to move and do all kinds of work. It also produces some heat that keeps our bodies warm.

- **Recycling in an Ecosystem using Solar Energy**

This means that the energy which makes human beings live, originally comes from the sun. It is absorbed by plants to make plant food. The plants are eaten by animals. The animals are eaten by us, human beings. We are then able to get energy to walk, work, dig, study, play and eat. This process is referred to in science as the food chain or the food web. The food chain is made up of producers, consumers, and decomposers.

An example of a simple food chain starts with a green plant getting energy from the sun; the plant leaves are then eaten by a goat; the goat is eaten by a man; which is finally eaten by a lion. This food chain is iIlustrated below in Fig. 3.d.

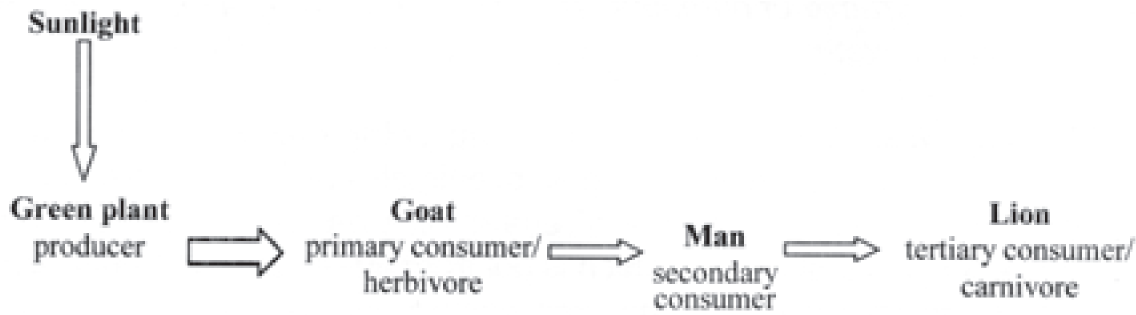


Fig. 3.d: A simple food chain

A food web follows a similar process, involving the sun, green plants, and consumers, as we see in Fig. 3.e below

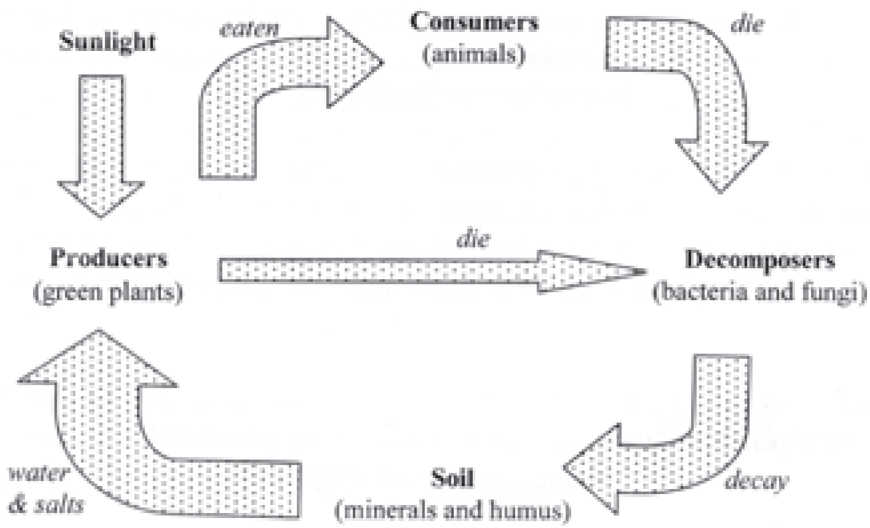


Fig. 3.e: A simple food web

The plants at the start of a food chain are frequently small in size, and large in number. At the end of the food chain the animals are often large in size, and few in number. The food chain can thus be represented as a pyramid of num.bers, in which the horizontal width of each step represents the biomass of the organism. In Fig. 3.f below are examples of pyramids of numbers:

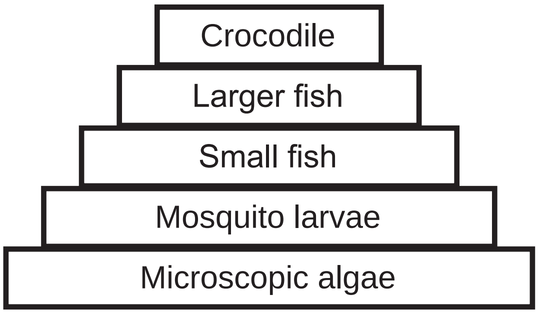


Fig. 3.f (a): A pyramid of numbers of organisms in water

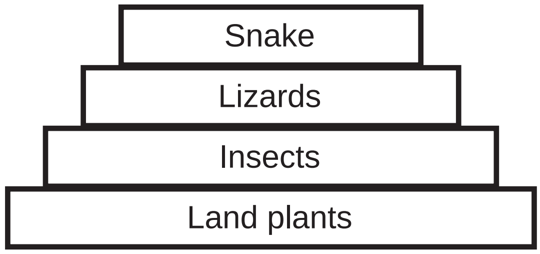


Fig. 3.f (b): A pyramid of numbers of organisms on land

3.2.2 Energy from Trees and Other Living Things (Biomass Energy)

Apart from the sun that freely gives plants, animals and human beings energy to grow, the next biggest source of energy in Uganda is biomass energy. Biomass energy is that energy which is got from any organic material such as trees, dry twigs, charcoal, garbage, crop waste, potato or banana peels, grass, papyrus reeds and many such dead and dried plant remains.

When biomass rots, it forms a gas called **biogas**, which largely contains methane gas. Biomass can also be turned in a fuel called **ethanol**. Both methane and ethanol can be used to cook food. Biomass can be burnt in a waste-to-energy plant to make electricity. Biomass can also be used directly to cook food, for example in the form of **fuelwood**.

In Uganda, 94% of the energy we use in our homes, schools, hospitals and industries is from biomass. For example, the majority of schools and homes in Uganda use firewood from trees for cooking. Tea factories in western Uganda also use a lot of firewood to dry the processed tea leaves. This is biomass energy.

Since trees provide most of the energy for our cooking and keeping ourselves warm in cold evenings, one would expect that many schools and homesteads would be growing a lot of trees to make sure they do not run out of supply of this important resource.

However, this is not the case. Most schools in Uganda that cook using firewood do not grow their own trees. They rely on buying from other people who sometimes cut down our natural forests (Fig. 3.g). Also, many homes do not grow their own woodlots. Instead, they go to swamps and tops of mountains to cut down any trees they can find. This has led to Uganda losing a lot of its biomass cover and natural forests. This is not good. If we continue like this, Uganda could easily turn into a desert. As young people who want to see our country remain green, we should take a lead to plant trees in our homes and schools. We should make sure that our schools and homes use firewood from the trees we plant on our land. This would save both our schools and our parents a lot of money. It would also save our natural forests from being cut down.

Fig. 3.g: Schools use lots of firewood daily; the trees are cut down from forests.

3.2.3 Wind Energy

Wind refers to moving air. It is air in motion. Wind is formed along a coast when the sun heats the water and the land below. Because land heats up faster than water, the air above the land will also become hot and start to rise. On the other hand, the water in a lake, river or ocean heats more slowly, and therefore does not rise, as does the heated air above the land. The cooler air above the water therefore moves in to fill the gap left by the heated air above the land. This air that moves from above the water, to replace the evaporated air rising above the land, is called wind (Fig. 3.h).

Fig. 3.h: How wind is formed

Because the sun will always shine and heat the earth surface, the wind will, therefore, always blow. This is why wind is a renewable source of energy.

Energy from the wind is trapped using a windmill. When wind blows, its energy turns the blades of the windmill, which in turn turns a generator. The generator pumps the water to produce electricity. Windmills produce clean energy. However, windmills cannot work everywhere. You need to make sure that wind will be blowing in that area every day. In Uganda, windmills are found in Karamoja, where their energy is mainly used to pump water from underground. But many of them are not in use at the moment. In some developed countries, many windmills are grouped together in a wind farm, to make electricity.

3.2.4 Geothermal Energy

Geothermal energy is heat produced in the earth‘s core by the slow decay of naturally occurring radioactive particles. Some places have high temperature of these decaying particles and can generate a lot of heat. If a well is drilled to tap this heat, the heat can then be used to create steam, which can be used in turn to spin a turbine. The turbine then turns the generator to produce electric energy. This process takes place in a setting similar to that iIlustrated in Fig. 3.i.

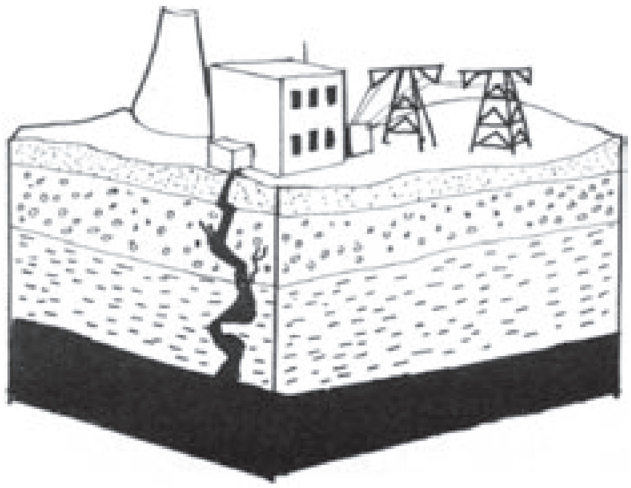


Fig. 3.i: Heat from the centre of the earth is used to make electricity

There are a few districts in Uganda where geothermal power could be exploited. This is particularly possible in areas near the East African Rift Valley, such as Kasese, Bundibugyo and Hoima districts. Because the earth core will always remain very hot, geothermal heat will always be available, so it becomes a renewable source of energy.

3.2.5 Hydropower

One of the cleanest energy sources in Uganda is electricity produced by water. This electricity is called hydropower or hydroelectricity; these words come from the word hydro which means water. The Owen Falls (Kiira) Dam in Jinja produces most of the hydropower used in Uganda. Most of the electricity for lighting in many big towns in Uganda is hydropower. Hydropower is also used in the many factories in Kampala, Jinja, Mbale, Lira, Mbarara and other major towns, to run huge machines. Many homes and schools in towns also use this electricity for lighting, cooking, ironing and watching television. Unfortunately, most hornes and schools in our villages do not have electricity because it is expensive to connect in remote villages. However, government has now started a rural electrification program. Many hornes and villages will have electricity in the near future.

A large area of the earth‘s surface is covered by water, in the form of ponds, lakes, streams, rivers, seas and oceans. When the sun shines on the earth, this water is heated and evaporated to form water vapour. This water vapour is in gas form, and is therefore added into the air around us. Additional water vapour is added into the atmosphere through transpiration by plants, and perspiration by people and animals. This water vapour is warmer and lighter than the surrounding air, which is cool, dry and heavy. Because the water vapour is lighter, it easily rises above the surrounding air that is heavy. As the vapour rises, it moves further away from the earth‘s surface and begins to cool. The water vapour condenses, changing it from gaseous form back to small drops of liquid water. These small drops of water accumulate to form clouds, which continue to rise above the earth, until they eventually gather and the small drops of water combine to form big drops of water. The big drops of water become too heavy to be supported by air, and eventually fall to the earth surface as raindrops. This rain again flows back into water bodies as run-off along the earth surface (especially down slopes like hills or mountains), or into the soil as ground water below the earth surface. This whole process is called the **water cycle** or **hydrological cycle**, and is iIlustrated in Fig. 3.; below:

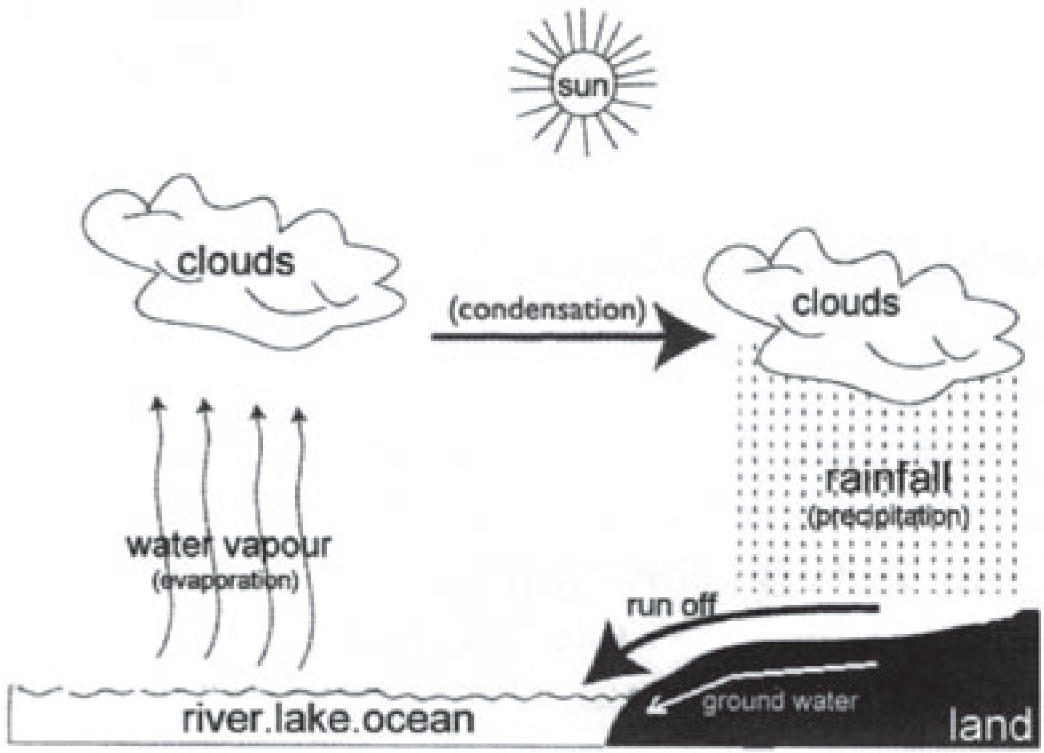


Fig. 3.j: The water cycle

When rain reaches the ground, it will always run from high ground to lower ground, under the force of gravity. The water will eventually collect to form a water body, such as a pond, river or lake. When a dam is built, we can easily control the fIow of water. Water then collects to form a ‚lake‘ called a reservoir behind the dam, and it is forced to escape through a narrow gate called a sluice. The sluice has a turbine which spins at very high speeds which in turn turns a generator to produce electricity. Because the water cycle will keep water moving all the time on Earth, we therefore call hydropower a renewable energy source.

The process through which we receive hydropower in our homes or schools involves several steps that take place in a **hydropower plant** or a **hydroelectricity plant**. This process of transporting electricity from the hydropower plant up to our homes or schools is illustrated in Fig. 3.k below:

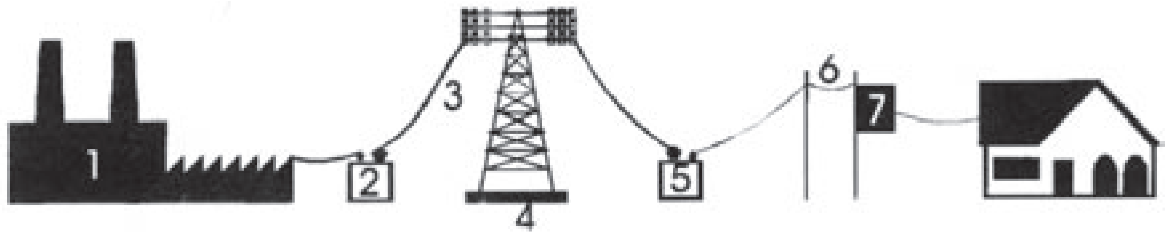


Fig. 3.k: Hydropower transmission

After electricity has been produced in the power plant (1), it moves to a step-up transformer (2), which increases the voltage (to reduce transmission loss). The electricity then moves to transmission lines (3), which are used to transport high-voltage electricity over long distances. The transmission lines are carried on power towers (4) at regular intervals of distance. The electricity then goes into a step-down transformer (5), which lowers the voltage for distribution to smaller lines. This lower voltage electricity is carried to our hornes and schools in distribution lines (6). Before the electricity reaches its final destination, a neighbourhood transformer (7) helps to lower the voltage even further. This ensures that the electricity can be used safely at school or at home without causing accidents, like the blowing of light bulbs or TVs, or without causing us to get shocked when we touch an electric switch.

3.3 Non-Renewable Energy Sources

3.3.1 Fossil Fuels

Many millions of years ago, the remains of animals and plants decayed in thick layers. These remains are organic matter. That means these animals and plants were once alive. As time went by, soil and mud changed to rock, covering the organic matter while exerting pressure on it. After millions of years, the pressure and heat build up, changing some of this organic matter into fossil fuels.

Fossil fuels include **coal, crude oil** or **petroleum**, and **natural gas**. Because these fossil fuels can get finished or exhausted and cannot be made quickly, we call them non-renewable energy sources. To reach fossil fuels that are deep underground, we need to use a drill.

The sun plays an important role in the formation of fossil fuels, because the energy in them comes from the sun. When these plants and animals were alive, they used energy from the sun to grow. When they died, the energy they had got from the sun remained in the decayed matter, and it is released when the fossil fuels are burnt.

Where organic matter such as fish and seaweed was buried under the oceans, this turned into natural gas and crude oil (or petroleum). Petroleum means ‚rock oil' or ‚oil trom the earth'. Colour may be yellow or black liquid. Petroleum and natural gas are formed as is shown in Fig. 3.1 below:

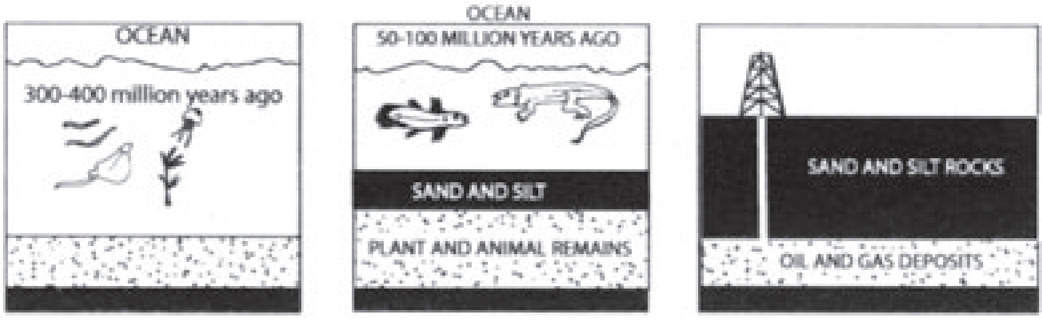


Fig. 3.l: How oil (petroleum) and natural gas are formed

Petroleum is refined or ‚made pure' so that we can get products that we can use, such as petrol, kerosene, diesel for fuel, and tar, for construction roads. During the refining process, the petroleum is heated. It contains different chemicals or ‚tractions', which turn to gas at different temperatures. As the chemicals turn to gas, they can be collected and turned into different products that people use, as we see in Fig. 3.m below:

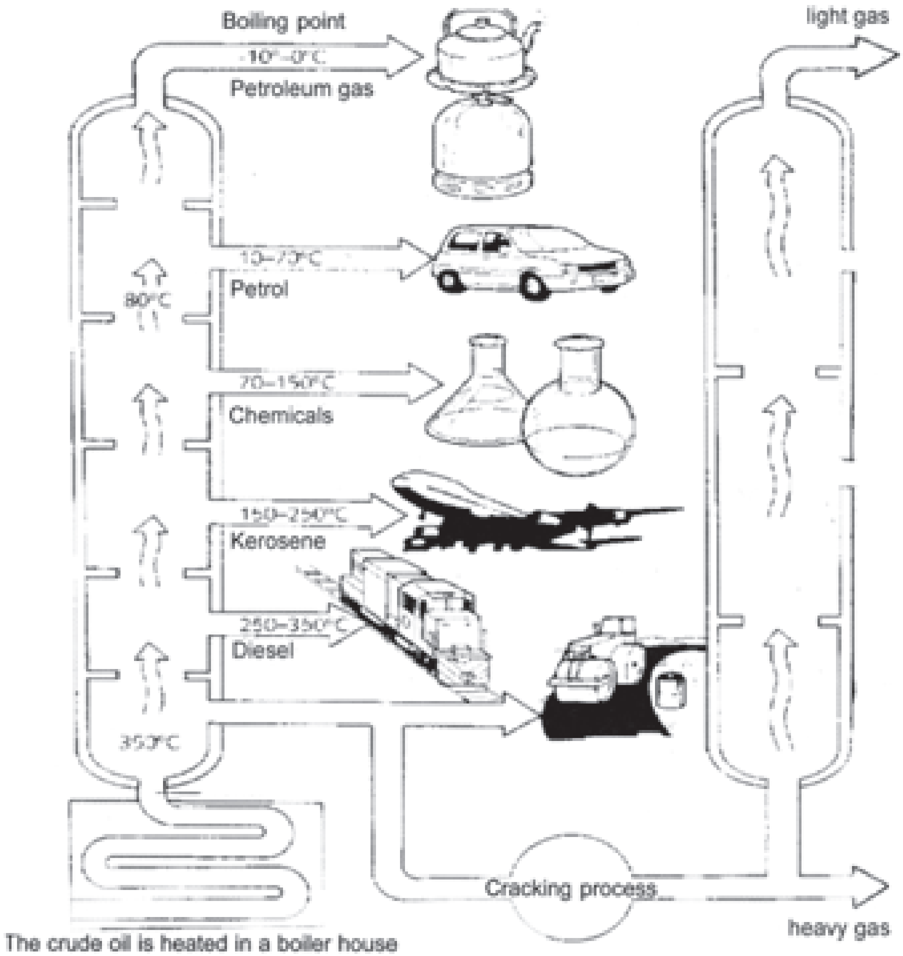


Fig. 3.m: The crude oi! refining process

There are other petroleum products that are common to us, such as inks, paints, petroleum jelly, detergents (such as bar soaps) and cleaning fluids (such as Jik).

All the petroleum used in Uganda is imported from other countries. However, it is now said that Uganda also has its own petroleum deposits around Lake Albert. In a few years to come, it is hoped that Uganda will also be mining and using its own oil.

Where organic matter, such as papyrus and reeds, were buried in swamps, it turned into coal after millions of years, as we see in Fig. 3.n. Coal is like charcoal, but more heavy and very black.

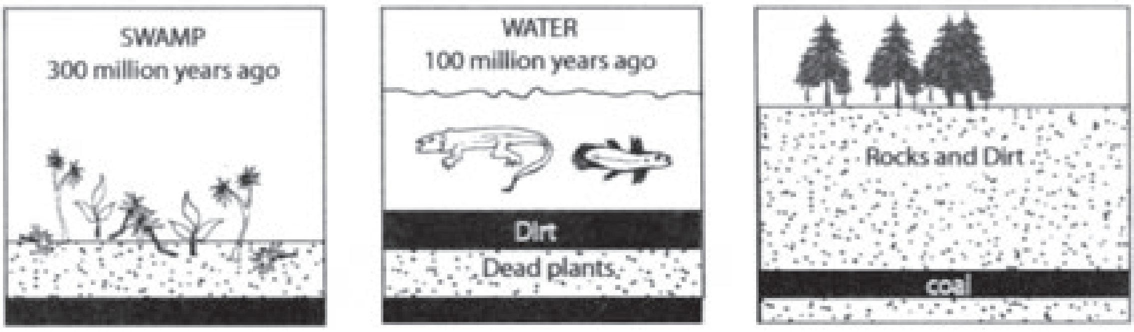


Fig. 3.n: How coal is formed

Products or derivatives can be extracted from coal through a process called destructive distillation. This process occurs as coal is burnt in an oven, under controlled air conditions, to give out different products, such as those in Fig. 3.o below:

Coal derivatives	Uses of derivatives
Coke	Fuel for making fires
Coal gas	Gas for heating and lighting many buildings
Coal tar	Thick, oil, smelly liqid from whcih many other by-products are got, such as falvourings, plastics, drugs like aspirin, synthetic rubber, tar to tarmac roads, nylon fibre, photographic chemicals, and dyes

Fig. 3.o: Derivatives of coal, and their uses

Coal is used in large factories to run machines, especially in developed countries like Britain and USA. When it is burnt in large chambers, the heat released produces enough electric energy to work huge machines used in these industries. However, the smoke that is released into the air after burning the coal can pollute the air. Natural gas is also converted to electricity in power plants, and used in large factories to turn huge machines.

However, using coal and petroleum in industries and vehicles causes air pollution, since it produces a lot of poisonous gases and fumes into the atmosphere. This is iIlustrated in Fig. 3.p below:

Fig. 3.p: Trucks use diesel made from fossil fuels, and release exhaust fumes that pollute the atmosphere

As they pollute the air, a thick layer of gas is formed in the atmosphere that does not allow any of the sun‘s excess heat to leave planet Earth. There is danger in burning fossil fuels, because a lot of heat is trapped around the globe. This problem is therefore given a special name; global warming.

Natural gas also causes pollution, but not as much as the other fossil fuels we have learnt about. This is why natural gas is being promoted in many countries to replace the use of coal or petroleum.

3.3.2 Uranium

Everything in the world is made up of molecules, which can be split further into very tiny particles called atoms. At the centre of an atom is a nucleus. The nucleus is made of even smaller parts called protons and neutrons. Moving around the nucleus are electrons. The electrons move around the nucleus in a circular form called a shell. This is iIlustrated in Fig. 3.q below:

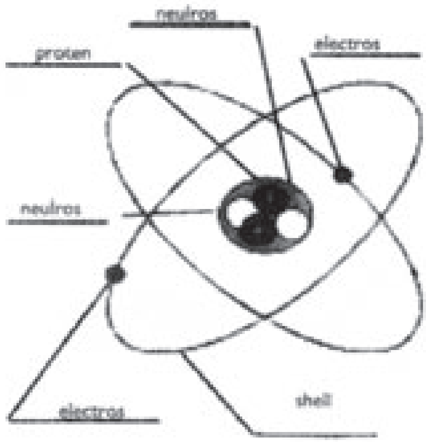


Fig. 3.q: The parts of an atom

The energy stored in the nucleus of an atom is called nuclear energy. The energy is released if the atom of uranium is split in a process called **fission**. In a nuclear power plant, a lot of energy is produced by splitting uranium atoms, which releases heat and radiation. This heat released is then used to produce electricity. This is possible because the heat generated in a nuclear reactor can be used to produce steam that turns the blades of a turbine which will propel the generator to produce electricity.

This form of energy is non-renewable because once we run out of uranium which is mined from the ground, we will no longer be able to produce nuclear energy. Nuclear energy is also very dangerous to people and other living things; when nuclear radiation gets in touch with living things it affects the growth and health, as we shall see in more detail in Chapter Six.

Summary of "Sources of Energy"

In this Chapter we have covered the following:

1. Renewable and non-renewable sources of energy
2. Where these sources of energy come from (or where they are found)
3. How each source of energy is important to living things

Every **source of energy** is important to people and other living things!

In the next chapter, we shall study how to capture, produce, and use energy in a way that causes as little wastage as possible.

CHAPTER 4

THE PRODUCTION AND EFFICIENT USE OF ENERGY

Objectives:

- *To explain the relationship between energy and matter.*
- *To learn how to produce energy.*
- *To learn how to use energy efficiently.*

4.1 Introduction to Producing Energy and Using it Efficiently

In the last section, we discussed what energy is and the different sources from which it is produced. In this chapter, we shall study how we can produce energy or capture it for our use. We shall also study how we can use energy efficiently without wasting it.

First, let us look at the relationship between energy and matter. In science, matter is defined as a substance that takes up space (has volume) and has weight (mass and density). In our lives, we need to use different forms of matter for our purposes. It may be for grinding maize into flour, so that we can make maize porridge. It may be chewing sugarcane, so we swallow the juice for our survival. It may be chopping a tree into small pieces for firewood, or chewing meat so that we can swallow it as food. All matter, therefore, is alike in one way: it can be changed.

There is one very important fact: **when we want to change matter from one form to another, we must use energy**. Energy causes change in matter, it makes things move, it helps us to change matter into the form we can use it for our daily lives.

Since energy is so important in our lives, we need to find ways of using every bit of it to help us do the work we want to do without wasting it. An example is lighting our room at night so that we can see properly. To have light at night we use energy. A light bulb uses electric energy, which costs money. If it is a paraffin lamp, it uses paraffin that also costs a lot of money. If we enter our room, we should switch on the light or light a lamp. Once we have finished what we are doing in our room and go out to join the family for dinner, we should switch off the light or put out the lamp. There is no need to have the light on in our room when there is nobody inside, or when daylight is sufficient.

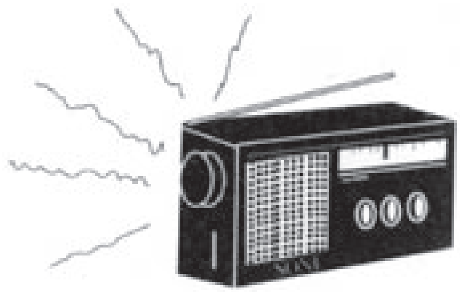
Many of us sometimes forget to switch off lights when we are not using them. This is a big waste of energy. The same applies to our radio. We should switch on the radio when we are listening. But if nobody is listening, for example, if we go to shower or to the toilet, we should switch it off until we return. This way, we are saving the energy from batteries. We call this energy conservation. To conserve energy means to use it only when you need it, without wasting it. When we use energy without wasting it, we can then say we are using energy more efficiently.

4.2 Producing or Capturing Energy

As we studied in Chapter One, there are different sources of energy and each source is important in our lives. Some sources of energy can be used directly; for example, we can use the sun‘s direct rays to see during the day, or to keep our bodies warm. Sometimes we need to change energy from one form to another before we can make use of it; for example, in order to use solar energy to light our televisions or light bulbs, we need to convert it to electricity using certain methods that we will discuss in Chapter 5.

However, we often cannot use energy in the natural form in which we find it. We first need to change it to another form; let us explain this further using the illustrations below (Fig. 4.a). If we want to see at night, we must light a kerosene lamp. This lamp uses kerosene or paraffin, which burns and gives us light. This is chemical energy that is produced by burning the paraffin, which is a fossil fuel. If we want to listen to the radio, we must put in batteries, which use chemical energy. This chemical energy in batteries produces electric energy, which turns some small electric components in the radio to produce sound energy.

Chemical energy in a paraffin lamp



Sound energy from a radio

Fig. 4.a: Objects in which energy transformations take place

From the examples above, you can see that every day of our lives, every second that we live, we are always producing and using energy. In every activity that we carry out, there is energy being produced and energy being used. Yet we must ask ourselves, where does this energy come from? How does it travel? How do we get it to do the work we want it to do?

4.3 Energy is Always There; it is Merely Transterred trom One Form to Another

In science, it is said that matter is neither created nor destroyed. It just changes from one form to another. For example, water boiling on the fire for a long time can become less and less in the saucepan. If we put 2 glasses of water in a saucepan and boil it for a Iong time, this may be reduced to one glass only. However, the water has not disappeared. It merely changed into steam or water vapour, and mixed with air around the saucepan. If all this water vapour was collected and cooled or condensed again, it would become liquid water again. We could then have our 2 glasses of water back.

When we put fire under the saucepan, some of the fire and heat energy get scattered. It heats up the air and the surroundings. This means, the energy produced is not all used for the original purpose that we wanted: to cook food. It is estimated that when we cook food on our traditional 3-stone cooking place (Fig. 4.b), only 10% of the heat is used to cook the food. The remaining 90% is scattered in the air and to the surrounding items.

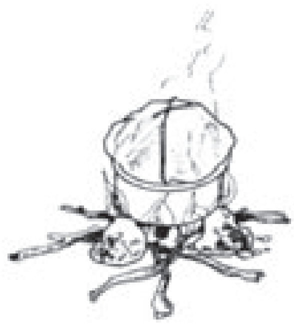


Fig. 4.b: The traditional 3-stone fire

Such a way of using energy is wasteful and very expensive. We are not using the heat energy from the firewood efficiently. We must discover ways of capturing all this energy that is scattered into the air, and use it for the main purpose of cooking food.

4.4 Using Energy Efficiently

In the example given above, when we cook on a traditional 3-stone stove, we lose about 90% of the energy. This heat energy, which is supposed to cook food, is lost to the air around us. This is a very big loss. Because firewood is also difficult to get these days, we find this is a really big waste. Many people in towns and in some villages buy firewood. If 90% of the heat from the firewood is wasted, this means we are losing 90% of the money we use to buy the firewood. This is not only a waste of firewood, but a waste of money as well, which money could have helped us to buy other things. The biggest challenge for us who do not like wasting energy and other resources, is to make sure we find ways of capturing most of the energy we produce so that we use it for the purpose we need it. If it is heat energy, how can we make sure we capture all the heat produced and use it all for cooking food? If we can succeed in doing this, then we can say we are using the energy efficiently.

4.5 Efficient Use of our Body‘s Energy

Before we can discuss how to use electricity, sunlight, firewood, and other forms of energy more efficiently, let us first think about our own bodies. Since it is our bodies that cook, connect electricity and split firewood, we need to know how to fix our bodies first. We shall look at two main aspects of our body‘s energy:

A. Energy-giving foods

B. Simple everyday tips that can help us to use our body‘s energy more efficiently

A. Energy-Giving Foods.

Our bodies need energy every day to get out of bed, walk to school, study, clean the classroom, help our parents to milk the cows, do homework, eat, sleep, and so on. The energy to do all this work comes from the food we eat. Our bodies also need to keep warm, and to fight any diseases that may attack our bodies. This kind of energy also comes from the food that we eal. We need to eat healthy foods, such as those in Fig. 4.c, in order to have enough energy in our bodies to live happily and healthily.

Fig. 4.c: Foods that give our bodies energy

When you look at the foods above, they can be grown in any part of our country. We can grow fruits and vegetables at horne and in our school gardens and compounds. We can even keep rabbits and bees using only our local materials to build a rabbit house and make beehives.

Since these things are easy to do at school and in our hornes, let us see how to carry out each of the steps in making a backyard garden.

❖ Setting Up a Backyard Garden

You can first practice this in your work group with your teacher at school by setting up group vegetable gardens in your school garden. Then you can work with your family and friends at home to set up a vegetable garden in one corner of your homestead near the kitchen.

First mix your soil with manure, for example from goats and cows, or with chicken droppings. Plant any local vegetables you find, which are rich in iron, such as *dodo, buga (red), nakati*, and *eggplants* (Fig. 4.d). Plant them in neat rows and each in its own section as illustrated below.

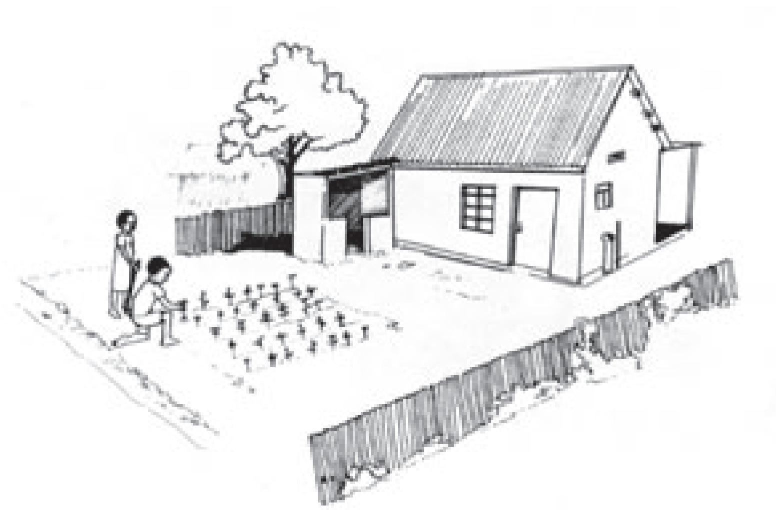


Fig. 4.d: Children planting vegetables in a backyard

Plant at least 5 sugarcane plants in one corner of the garden, which has good rainwater drainage (Fig. 4.e

Fig. 4.e: Children planting sugar cane in a backyard

Plant your 10 cassava sterns in a li ne and leave at least 1 rnetre in between each stern, as in Fig. 4.f below

Fig. 4.f: Children planting cassava in a backyard

Plant fruit trees in your compound and around your garden boundary (Fig. 4.g). For example, you could plant a mango tree, pawpaw trees and avocado trees

Remember to water your plants every morning before sunrise, and every evening, especially during the dry seasons.

B. Tips for Reducing Energy Use

There are things we do every day at home after school, and on weekends, which make our lives very difficult. We can make these simpler and save a lot of energy. Try out the following examples:

i) Fetching Water

Many children in villages have to fetch water from long distances. They have to carry water on their heads. Combine with a friend and make a wooden wheelbarrow using sticks from your garden. You can use a wooden wheel for your wheelbarrow, like the one in Fig. 4.h. This will save you a lot of energy to push jerry cans of water on the wheelbarrow instead of carrying them on your head. You can even push two jerry cans at a time so you don‘t have to go to the well twice.

Fig. 4.h: A boy carrying jerry cans of water on a wheelbarrow

If you have a bicycle, you can use it to carry jerry cans of water, as we can see below in Fig. 4.i. Have the bicycle oiled all the time. Check the pressure in the tyres to make sure there is enough. With a bicycle you can carry 2 jerry cans at a time, and yet spend less energy.

Fig. 4.i: Children carrying jerry cans of water on a bicycle

In fact some people who fetch and sell water in bigger towns can carry up to ten jerry cans on their bicycles (Fig. 4.j). They save a lot of energy because they only need energy to push the bicycle, since it carries the jerry cans for them.

Fig. 4.j: A man carrying 10 jerry cans on a bicycle

Can you imagine haw much energy they would use if they had to carry all ten jerry cans on their shoulders? Carrying 10 jerry cans on your shoulders is very difficuit, and needs a lot of energy, as we can see in Fig. 4.k. The stick could easily break, you could collapse under the weight of the jerry cans.

Fig. 4.k: A man attempting to carry 10 jerry cans of water on his shoulders

ii) Washing Dishes

Wash the dishes immediately after each meal. If you cannot wash them immediately, then soak them in water until you are ready to wash them. Do not allow food to dry on plates. It will take more energy to wash the plates when dry food is stuck on them.

iii) Washing Clothes

When you wash your school uniform and other clothes, soak them in water overnight. It will be easier to wash them, and it will take a shorter time in the morning (Fig. 4.l).

Fig. 4.l: A girl washing soaked clothes

iv) Drying and Ironing Clothes

After washing your clothes, do not wait until your clothes are too dry (Fig. 4.m). Remove them fram the sunshine when they are slightly damp; it will be easy to iron them. Also, you will not use too much of your body's energy, or too much heat energy (from a charcoal iron or an electric iron) when ironing the clothes.

Fig. 4.m: A girl picking clothes from the fire when they are still a bit damp, and ironing them with ease

Summary of "The Production and Efficient Use of Energy"

In this Chapter we have covered the following:

1. The relationship between energy and matter
2. How to produce or capture energy
3. How to use energy efficiently, or without wasting it

Energy has a strong relationship with matter, and many other things. Because energy is so important, when we produce and use it, we should never waste it.

<u>We must use energy efficiently if we are to survive</u>

In the next chapter, we are going to learn about "energy conservation", and explore the different "energy conservation technologies".

CHAPTER 5

ENERGY CONSERVATION TECHNOLOGIES

Objectives:
- *To explain the term energy conservation.*
- *To learn different technologies used to conserve the various sources of energy.*

5.1 What is Energy Conservation?

The term energy conservation means using an energy source efficiently, without wasting it or exhausting it. For example, when we want to use firewood for cooking, we must minimise wastage and use only that amount of firewood with which we need to cook the food. The rest of the firewood can be saved for later use.

Likewise, when we should not waste the electricity that we use to light up electric bulbs when we want to read in a dark room. We should only switch on the light bulb when we enter the room, and switch it off when we finish reading and leave the room.

This Chapter will concentrate on how to use energy efficiently, while minimising wastage. In order to use energy without wasting it, there are two key points wee must remember:

- We should use energy that we can make ourselves and keep renewing so that it does not run out. This kind of energy is renewable energy, as we learnt in Chapter Two.
- When using energy, we must always check to see whether there is a wastage. If there is energy being wasted then we must think of how to conserve it. This means using energy wisely, so that it does not easily get exhausted.

Energy conservation is best done using technologies to conserve energy. A technology is a scientific invention that helps us to do work more easily. Therefore, an **energy conservation technology** is a scientific invention that helps us to do work more easily, while minimising the wastage of energy. We shall now learn about the various energy conservation technologies of some sources of energy that we studied in Chapter Three.

5.2 Solar Energy Conservation Technologies

Here we shall look at solar energy, and those technologies that use the sun‘s heat as a means of conserving energy.

5.2.1 Solar Energy and its Importance to Living Things

As we learnt in Chapter Three, solar energy is the energy from the sun. When we look all around us, everything that we see alive, fresh, and full of life, uses energy from the sun. If the sun stopped shining for a long time, everything you see alive would die, including human beings, plants and animals (Fig. 5.8). Wind would stop blowing, and water would stop flowing and freeze to ice. The moon would not shine, there would be no rain - even cars would not move because the fuel and water-cooling system would freeze. Isn‘t that really amazing! Think about it again. Without solar energy, everything on earth would come to a standstill. This is because solar energy is the most important energy that keeps things on earth alive.

Fig. 5.a: Solar energy keeps all living things alive, like those above

Without Solar energy, nothing on earth would survive.

One of the most important uses of the sun is that it radiates heat energy. This heat reaches the earth and heats the ground and the water. This is what keeps the earth warm and free from freezing. When the earth is warm, plants can grow, flowers and fruits blossom, bees make honey, and winds can blow.

The heat makes human beings keep warm and strong. That is why many people who live in cold countries like England come to countries near the equator. Countries like Uganda have sunshine all year around, so tourists can enjoy a holiday in the sunshine, while it is winter in their own countries (Fig. 5.b).

Fig. 5.b: Tourists lying on the beach in the sun

During the winter season in some countries, no plants can grow. Even when the sun is shining and you stand outside with no clothes, you can also freeze like a rock of ice. You need to put on very thick clothing to keep warm.

In such places, however, people can build houses with big glass windows to let rays of sunlight enter the house, like in Fig. 5.c. When the sunrays get inside, they come with the radiant heat that is trapped inside by the glass and keeps the room warm. Even if it is very cold outside, inside the house the glass does not allow the heat to go out. It also keeps out the cold.

Fig. 5.c: A man enjoying sunshine from the inside of his horne

5.2.2 Technologies that Use Solar Energy

In cold countries, farmers also grow crops inside the house. Because all the crops outside die when it is very cold and snowing, farmers grow plants in houses made of glass. These houses are made of glass on top and on the sides, and are commonly called greenhouses (Fig. 5.d). The glass walls and roof allow in whatever little sunshine to come in through the glass. The sunlight gives off heat, which is trapped inside and keeps the greenhouse warm. This helps the plants such as cabbages, tomatoes and flowers inside the house to grow, even when everything outside is covered in snow

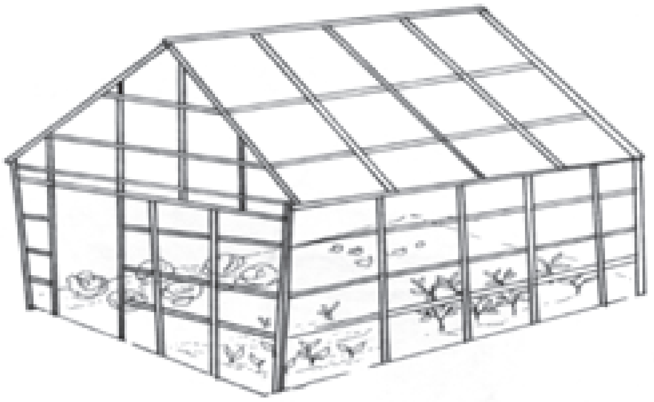


Fig. 5. d: A greenhouse with vegetables growing within

i. Solar Water Heating

In Uganda, some houses and hotels use the sun for heating water. Instead of bathing cold water in the mornings or nights, people use the sun to heat water. This is done using solar panels (illustrated in Fig. 5.e), which capture the sun's heat, and concentrate it. This heat is used to heat cold water passing underneath it. The hot water then goes to an insulated tank, which keeps it warm for use. At Sarova Lodge in Murchison Falls National Park, for example, all the water for guests in about 50 rooms is heated using solar heaters.

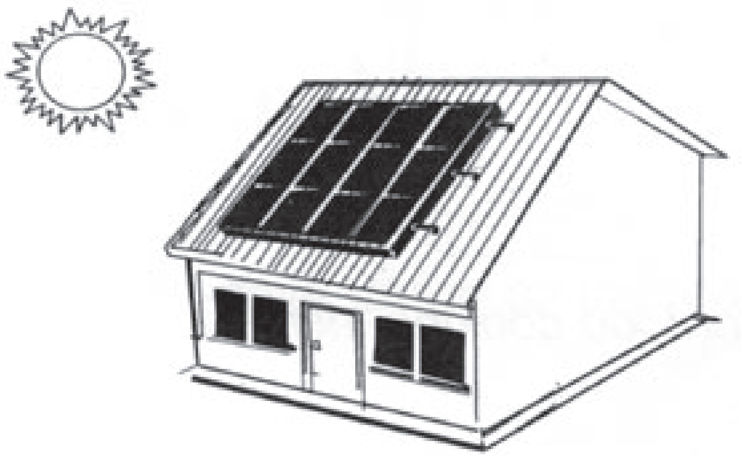


Fig. 5.e: Solar panels on a rooftop

ii. The Solar Cooker

Technologies have now been developed which can help us to cook food using heat from the sun. These are called solar cookers. Solar cookers can now be used to boil tea, cook food and bake cakes. You can even cook matoke and meat in a solar cooker or solar oven.

In Uganda there are two types of solar cookers that are being promoted mainly by some Non Government Organisations (NGOs):

a) Direct Solar Cooker

This type of solar cooker is made like the inside of a big half ball or bowl. Shining metallic sheets or aluminium-coated paper is placed all around the bowl in such a way that all the sun rays are reflected to one point, which becomes very hot.

The pot of food is placed at this hot point and is cooked directly by the concentrated solar energy, as is shown in Fig. 5.f below:

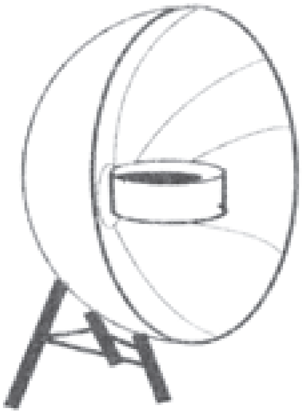


Fig. 5.f: A saucepan of food cooking inside a direct solar cooker

b) Indirect Solar Cooker

This is a box with all its sides and bottom insulated or stuffed with material that can not allow heat to escape. The top is covered with glass. The solar energy is reflected by an adjustable reflective screen, which reflects concentrated energy into the box. The heat entering the box is trapped by the glass and insulated sides and cooks the food inside (Fig. 5.g).

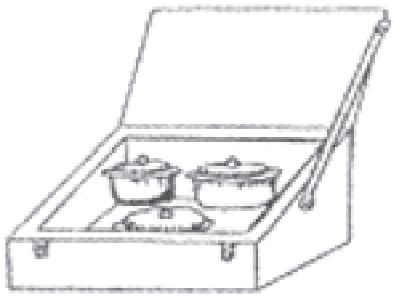


Fig. 5.g: Pots of food cooking inside an indirect solar cooker

iii. Solar Driers

Solar driers are used to dry foods, using the sun's heat. Solar driers may be done either traditionally, or with improved solar driers, as we shall explain below. .

a) Traditional Solar Driers

Traditionally, solar energy has been used to dry food, seeds, medicinal herbs and clothing such as bark cloth and hides and skins. Solar energy is therefore the major traditional technology for preserving foods and seeds so that they can be stored for a long time. The major items dried and preserved using solar energy include food crops and cash crops, such as those in the table below.

Food Crops	*Maize, cassava, bananas, fish, mushrooms, groundnuts, beans, peas*
Cash Crops	*Coffee, tea, tobacco*

Traditionally, drying is often done on a mat (Fig. 5.h) or directly on a swept ground, on a roof (Fig. 5.i), or on a raised rack (Fig. 5.j).

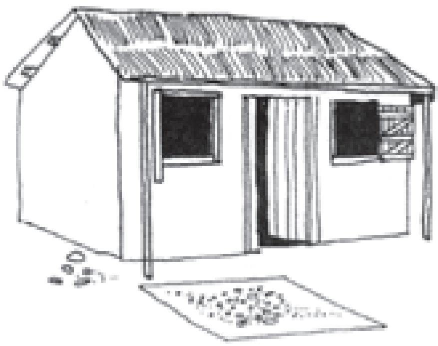


Fig. 5.h: Food being dried on a mat and some on swept bare ground

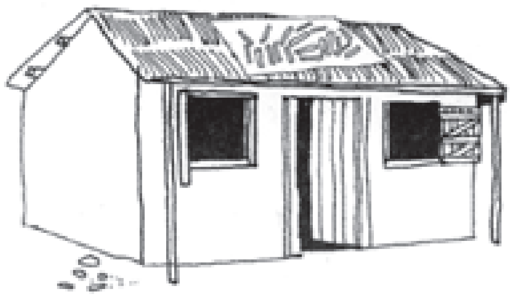


Fig. 5.i: Pieces of cassava drying on the roof of a house

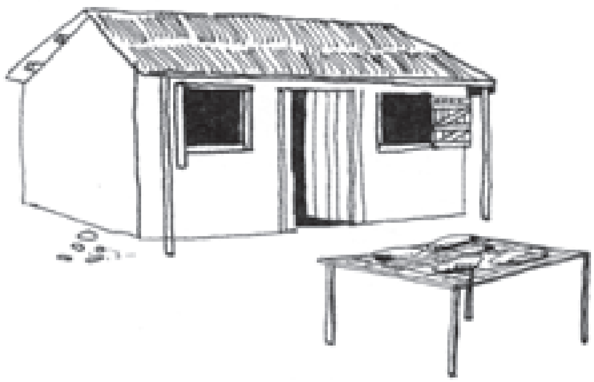


Fig. 5.j: Fish drying on a raised rack

b) Improved Solar Driers

In Uganda, we produce a lot of fruits including bananas, such as bogoya, sweet bananas, pineapples, oranges and mangoes. Many countries overseas would like to buy these fruits from us. Unfortunately, if we have to send these fruits fresh, they get rotten before they reach the market overseas. Another marketable product is mushrooms. We can now grow mushrooms in big numbers inside a house and can sell them overseas at very good prices. However, these mushrooms need to be preserved for export.

The best and cheapest way to preserve both fruits and mushrooms in big numbers is by using solar energy. If we dry these fruits in the sun in open air like we do traditionally, the overseas buyers can not accept these products. This is because they may get dust in them and other dirty things. Our products will be contaminated and will be rejected.

This is why in Uganda, scientists have now developed an improved solar drier, illustrated in Fig. 5.k. The solar drier is built like a box with plastic sheets, which resist sunshine. These are the cheapest materials. We can also build a bit more expensive driers using glass to allow in sunrays and heat to go in but not to go out. We only leave some holes on the side for the water (moisture) from the things being dried to escape. The solar energy drier ensures that the products remain clean, and dry more quickly than in an open air drier

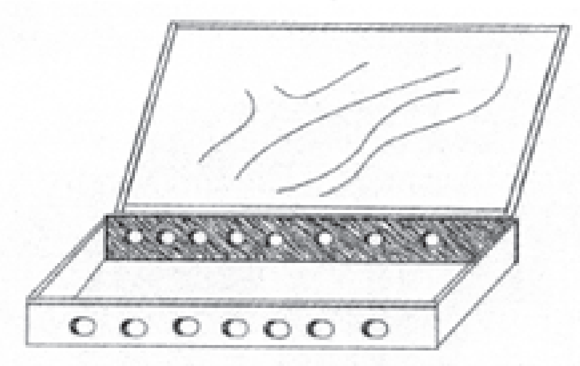


Fig. 5.k: An improved solar drier made of glass

iv. Solar Electricity

Scientists have also developed a new technology to turn solar energy into electricity. They have developed what they call solar cells or photovoltaic cells. Photovoltaic comes from the words photo, which means light, and Volta, the name of a famous scientist. The solar or photovoltaic cells are made of two pieces of silicon. Silicon is the main ingredient of sand that we commonly find near our rivers or lakes. Each silicon has a different chemical added. When radiant energy from the sun hits the photovoltaic (PV) cell, the chemicals cause electricity. These PV cells are made of thin slices and can break easily. So they are carefully put in a glass case. To get usable voltage or power, a number of these PV cells are connected together in series (one after another) and put in a glass casing. Groups of these PV cells connected in series and protected in glass and plastic frames are called solar modules or photovoltaic modules. Just one solar module is able to light up four to five bulbs, operate a small television set, and play a radio.

More solar modules can be joined together to produce enough electricity to light a house with even 20 bulbs, run a refrigerator and a colour television and even a computer. Smaller modules are available to light even one bulb or run a small radio. There are even smaller PV cells that can operate a watch or a calculator. Some PV cells are even connected to a lamp so that instead of a kerosene lamp, you can buy a solar one. When it goes down, you put it outside in the sun and it is recharged.

Photovoltaic cells can also be used to provide electricity to big hospitals and schools. It is good for schools and institutions, which are far from the main hydro-electricity lines. Even individual homes can buy their own unit and connect their own electricity, unlike hydroelectric lines, where you have to wait for a line to connect the whole village or town.

Solar electricity is initially expensive to connect. However, once connected in a house or school, there is no need to pay continuous bills to the electricity company. You only need to buy your own unit.

The solar electricity unit is made up of three parts, namely, the PV cells or modules, the battery and the system control (Fig. 5.l). Let us look at the role each of these components plays:

a) Photovoltaic cells or modules

This is the major component of the solar electricity because it is these cells that actually capture the sun‘s radiant energy and chemically convert it into electricity.

b) Battery

This is used to store the electricity produced by the solar module. The battery stores this electricity in a chemical form by charging lead acid in the battery. This battery is charged during the day. At night the stored energy is then used for lighting. During the day and night the stored energy in the battery can be used for playing a radio, television, operating a computer or even a refrigerator.

c) System control

This is composed of wires, switches and electric fuses, wh ich are used to monitor and control the electricity being produced and the electricity that is being used (input and output). This control system protects the battery from being overcharged or excessively discharged.

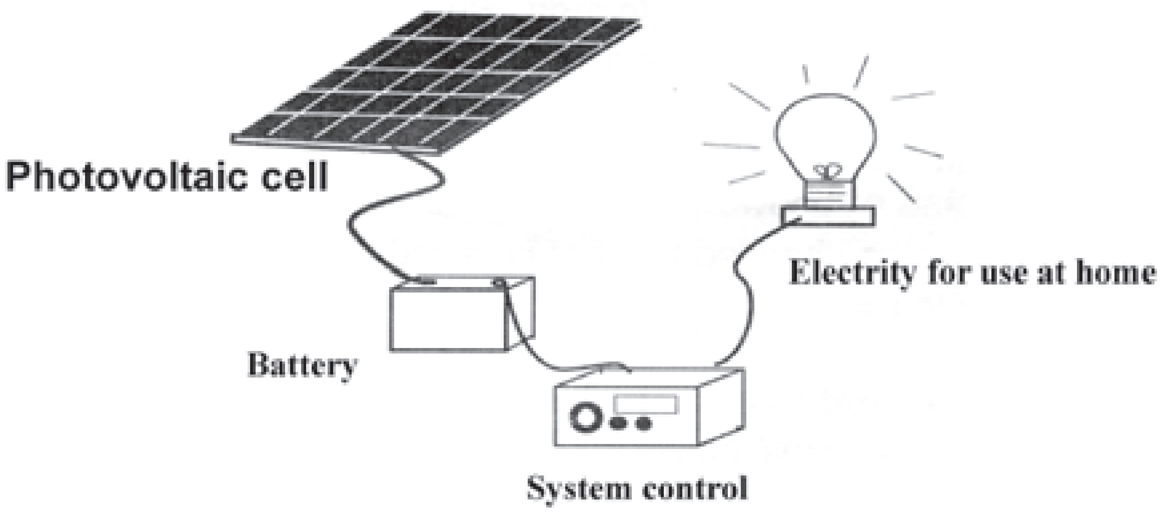


Fig. 5.l: Three major parts of the solar electricity unit

5.3 Conservation of Biomass Energy

In this section we shall see how to conserve biomass energy. As we learnt in Chapter Three, biomass energy includes both fuelwood and biogas. We shall look at the different technologies in these two kinds of biomass energy.

5.3.1 How Biomass Energy is Produced

In Chapter Three, we learnt about the process called photosynthesis, through which green plants absorb and use solar energy make their food. As the plants grow bigger and older, more and more of this energy is stored in their stems, branches and leaves. Even when the plant ‚dies‘ or dries up, the sun‘s energy remains stored within the dead plant.

When we light a piece of wood and it is heated to about 250 degrees Celsius, the wood starts to release the energy that it had absorbed from the sun, as gases. At about 650 degrees Celsius, these gases start to burn and give off very strong heat. It is the burning of these gases that we see as fire. In reality, wood itself does not burn; rather it is the stored gases that it releases which give us heat energy in the form of fire.

5.3.2 How to Conserve Biomass Energy

In conserving biomass energy, our aim is to use as much of the energy from firewood and charcoal as possible. Improving the efficiency of any wood burning stove means using less wood to perform the same task. This will reduce the amount of wood we need to use, and also reduce costs of buying wood. It does not matter whether the stove is the primitive type, a large factory boiler, or an electric power station; what matters is how efficiently fuel is being used in the stove.

As we saw in Chapter Four, the traditional, open, three-stone fire is the most commonly.used firewood stove in Uganda. However, it is also one of the most wasteful stoves, because it uses a lot of firewood, but most of its energy is lost to the surroundings. Only 10% of the wood‘s energy is used for cooking, while 90% is wasted into the surrounding air.

All this wastage of energy has led to what is called the fuelwood crisis, as we shall see below in more detail.

❖ **The Fuelwood Crisis**

Fuelwood has very many uses, as we see in the examples in Fig. 5.m below. The number of people who need to use fuelwood has continued to grow at a fast rate, leading to a high demand for fuelwood.

Cooking using firewood

Ironing using a charcoal iron

Keeping warm using firewood

Roasting meat using charcoal

Fig. 5.m: Examples of uses of fuelwood in Uganda

According to recent statistics, most cooking in Kampala is done using charcoal (72%) followed by firewood (11%); while in rural areas around Uganda, most people cook using firewood (98%) followed by charcoal (1%). Other means of cooking, such as electricity, gas and paraffin are used in even smaller amounts.

Another cause of increased demand for fuelwood is the activity of brickmakers. Brick-making projects are increasing in every village and town due to more people who want to build permanent houses. Unfortunately, brickmaking uses a lot of fuelwood, as is illustrated in Fig. 5.n. For example, a big brick kiln for 10,000 bricks can use a full lorry of wood

Fig. 5.n : Offloading a lot of firewood to baking bricks

To feed a school of 500 students for one term of 90 days, you need about 15 lorries of dry firewood. To bake a ton of lime in Tororo district, one uses about 3 lorries of firewood. Due to this high demand for fuelwood, many trees have been cleared from forests, bushes and family plots (Fig. 5.o). People have now resorted to cutting down mango trees to use for bricks.

This is very dangerous indeed considering that in such areas there is prolonged drought due to lack of vegetation cover to control the climate.

Fig. 5.o : A man cutting down trees in a forest

In all these problems, women and children who are the main providers of fuelwood have to walk increasingly long distances and spend long hours searching for firewood. Especially for school-going children, this has limited their time for revision and homework, contributing to their poor performance at school

❖ Indicators of the Fuelwood Crisis

A number of indicators or signs show us that fuelwood has reached a crisis stage in many parts of Uganda, and we have to do something about it urgently:

- In many areas, firewood that used to be free and in plenty now costs money. In villages or town suburbs, where there is little cash income this is a very serious problem to poor families. The prices of fuelwood have continued to increase all around the country.
- There is more time spent on collecting firewood.
- Women and children have to travel longer distances to collect wood. Even school trucks have to travel Ionger distances for fuelwood, spending more money in transport costs.
- Alternative sources of fire are now being used. In some villages, for example in the districts of Kumi and Tororo, some families have to use dry grass to cook. In parts of Rukungiri district and other parts of Uganda where people have cleared all their land of trees to make grazing land, some families use dry cow dung to cook. This produces little heat and a lot of smoke and bad smell.
- In other parts of the country, many families eat food that is not properly cooked due to fuel shortages. They do not have enough fuelwood to cook foods such as dry beans and peas, which take a long time to cook.
- Some families cook only one meal a day or have to eat cold food to save on fuel-wood.

❖ Possible Measures to Address the Fuelwood Crisis

There are solutions to the fuelwood crisis that can be divided into two major categories:

Reducing the demand or use of firewood by:

- ○ Improving the efficiency of fuelwood use by using stoves that cook more food, using less fuelwood, as in Fig. 5.p below:

Fig. 5.p (a): This open fire uses a lot of fuel but cooks very little food

Fig. 5.p (b): This stove uses little fuel to cook a lot of food

- ○ Use methods that use less firewood to produce more charcoal.
- ○ Use alternative biomass fuels instead of fuel wood, such as biogas from animal wastes, charcoal briquettes made from agricultural wastes such as coffee husks and banana peels, agricultural wastes such as sugarcane bagasse.

Increasing the supply or production of more fuelwood by:

- ○ Planting more trees on family plots, in schools and on other institutional land.
- ○ Planting large wood tree plantations, especially on large vacant land, government land and fragile ecosystems such as hillsides, riverbanks and lakeshores.
- ○ Improving forest management.
- ○ Planting special trees that are fast growing, agroforestry trees that can be grown together with crops, trees that are hard and burn slowly but produce a lot of heat, and corpsing trees (Fig. 5.q) that rejuvenate themselves and grow again after harvesting the mother tree.

Fig. 5.q: Coppicing trees growing anew

The process of planting trees is called afforestation. It is the deliberate action of planting forests or smaller woodlots, for purposes of increasing fuelwood production, building poses, and other wood products. It is usually advisable to locate an afforestation project where the land is not suitable for agricultural crop production.

We also need to replace trees that we cut down in forests, since many of us get our fuelwood from forests. The process of planting trees on land that used to be a forest is reforestation. This is a deliberate action to replace trees that have been cut down formerly, from forested areas or gazetted forest reserve land.

For a successful afforestation or reforestation scheme, one must establish a well-planned tree nursery. Whether at family, village or school level, there is need to have practical skills in establishing a good tree nursery.

❖ Tree Nursery Establishment

To establish a family or school woodlot it is not advisable to buy seedlings. This can be too expensive. You should establish your own nursery near the place you plan to plant your trees. Follow the steps below and you will have a good, admirable tree nursery in around three months.

Consider the following points when choosing the seeds to plant in your tree nursery:

- Decide on which tree species you want to plant in your plot.
- Collect and dry the seeds. Pick seeds only from a healthy mother plant.
- These are seeds that you collect locally from a forest or elsewhere. They are not pre-treated. Be selective and timely when collecting such seeds, and collect them from the best parent trees. Do not mix seeds of different species as each of them has specific viability and germination conditions.
- Those seeds which need to be extracted from their „container“ must be done carefully so that we can store the seed. If seeds are in cones, such as those of pines, dry the cones and gently thrush them to get the seeds out. Some seeds come out dirty after extractions. Clean them before storage. If there is need to store seeds, put them in a dry, cool, and possibly dark place. Label each container, the type ot seeds and date of collection.
- Seed viability refers to the ability of the seed to germinate when planted. To find out whether your seeds are viable, drop them in water. More often than not bad seeds will float while the good one will sink to the bottom of the container.

Consider the following points when siting where your nursery should be:

- It should be near where you are going to plant the trees permanently.
- The ground should be level or terraced.
- Water must be near and always flowing.
- The soil must be fertile.
- For proper distribution of light, align the nursery on the east-west direction.
- Fence it out to keep out intruders and domestic or wild animals. Ensure man power is always enough.

Follow these steps when preparing your seed beds:

- Clear the area of all weeds. Select an area with good loam soils. Loosen up the soil by digging, and especially remove all scotch grass and any roots of other plants

Fig. 5.r

- Measure out your seedbeds at 3 feet wide and 10 to 30 feet long. Leave 1 or 2 feet between each seedbed.
- Add a mixture of sand and manure to your soil and mix. Manure should be 2 basins to one of sand, to about 10 basins of ordinary loam soil. Mix the soil well in each sand bed with a hoe or spade.

Fig. 5.s

- Put tree planks or banana sterns around each seedbed. This is to stop the mixture trom being washed away by rain or scratched away by the chicken. Hold the plants or banana sterns firmly using pegs on the outside.
- Use a rake or your hands to spread out the soil evenly.
- Erect a shade for each seedbed to stop the sunshine or direct rain trom reaching your soil mixture. Cut your tree support 5 feet in front and 4 feet at the back. Dig holes of 1 foot and put it in the supports. The shade should be built in such a way that the higher side faces where the sun comes in. This will allow the mild morning sunshine to reach your seedlings. The shorter supports of 4 feet should be at the back. This will allow the shade cover to stop the strong afternoon sun from hitting and damaging the plantlets.

- Build a shade with cross beams and cover with grass or dry banana leaves. The thatching on top should not be too close. This is to allow some bits of sunshine and rain to reach your plants.
- When sowing the seeds, use a stick or your forefinger to scratch straight lines lengthwise in your soil mixture. The lines should be about 1 centimetre deep. Spread your selected seeds along the deep lines in the soil.
- Cover the seeds with the soil again or with a thin layer of the soil mixture
- Mulch or cover the seedbed with dry grass after sowing the seeds.
- Water the seedbed using a watering can. If you have no watering can, get an old tin and make small holes with a nail. Keep filling the can from a basin full of water and let the water drip through the buttonholes of the can. If you cannot find a can, use your hands to sprinkle the water all over the seedbed. Avoid pouring handfuls of water on the seedbed.

Fig. 5.t

- Keep watering twice a day, early morning or late evenings, especially during the dry season. Make sure you water the seedbed at least once a day. If it is a rainy season, there is no need to water.
- Keep removing the grass mulch to check if the seeds have germinated. As soon as the seeds have germinated, remove the mulch.

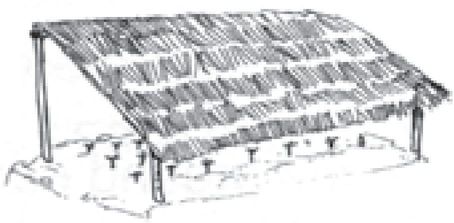


Fig. 5.u

- If you have polythene pots you can transport the seedlings into pots full of soil mixture and keep watering thern. You can make pots from banana fibres, put soil and transplant them. Do not allow any weeds to grow. However, if you have no pots, do not worry. Do not remove the seedlings at all. Make sure in sowing you leave a bit of space between the seeds. Allow the seeds to grow normally. During the wet season, dig holes and scoop your seedlings with some soil, carry it in a basin and plant it. It will grow normally.

5.4 Biomass Energy Conservation Technologies

Let us now look at traditional cooking stoves, and examples of improved cooking technologies.

i. Traditional Cooking Stoves

Two types of traditional stoves are commonly found in Uganda, namely the three-stone fire and the traditional charcoal stove (or *sigiri*).

- **Traditional Three-Stone Fires**

This is a typical rural Ugandan stove. It is commonly used in Uganda.

Fig. 5.v: The traditional 3-stone fire

Although this open fire is used in many homes, it has many disadvantages:

❖ It uses a lot of firewood.

❖ It is difficult to use during windy or rainy weather, because wind and rain can easily put out the fire.

❖ Up to 90% of the heat produced by the fire is lost to the surroundings. Only 10% of the heat produced is actually used to cook the food.

❖ It is a health risk to people because it produces a lot of smoke, yet smoke is not good for the lungs and eyes. It can cause serious lung problems and eye irritation. This open fire can easily burn the person cooking, or burn children playing in the kitchen.

- **Traditional Metal Charcoal Stoves (sigiri)**

This stove is made out of metal. It is made by many small industries (cottage industries) in Uganda, such as Katwe in Kampala. This stove is commonly called a *sigiri*.

Fig. 5.x: The traditional charcoal stove

However, this stove also has many problems: It uses a lot of charcoal.

- ❖ It loses much of the energy produced to the surroundings. This is because it is made of a thin layer of metal, which easily gives off heat. The metal does not store heat weil, and is therefore called a poor insulator of heat.
- ❖ It is also a risk to people because it produces a lot of smoke, and the metal can easily bum someone's skin when the *sigiri* is hot.

ii. Improved Cooking Stoves

Improved cooking stoves are energy efficient technologies, because they use little fuelwood to do a lot of cooking. Most of the heat energy produced by the fuelwood in these stoves is used to cook the food; it is not lost to the surroundings.

Improved cooking stoves have the following advantages over the traditional stoves that we looked at earlier:

- ❖ They use less firewood to do the same amount of cooking than traditional stoves.
- ❖ Most of the heat produced by these stoves goes directly to the saucepan to cook the food. Less heat is lost to the surroundings because they are made of materials that store heat. These materials are good insulators of heat.
- ❖ Less time is spent cooking food, because much of the heat produced is trapped in the stoves and this cooks the food more quickly.
- ❖ They are not a risk to people because they produce no smoke, or very little smoke. They are also made of materials that do not easily bum the skin.
- ❖ They are easy to use, because they are built in a way that allows you to easily cook while sitting or standing.

We shall now look at two improved stoves that can be used for firewood, and two more improved stoves that can be used for charcoal.

- **Rocket-Lorena Stove**

The Ministry of Energy and Mineral Development through the Energy Advisory Project (EAP) has now developed an improved and much more efficient Lorena stove, called the Rocket-Lorena Stove.

Although the principles of construction are similar to the original Lorena stove, there are three new outstanding features:

1. It uses a rocket arm combustion (burning) chamber that allows enough height for the surrounding air to burn the firewood, and reach the saucepan at its highest temperature.
2. There is a firewood shelf that allows free air to continue flowing below the firewood and mix with the gases being released by the firewood. This gives the best formula for complete combustion of the gases.

3. There is insulation all around the combustion chamber to ensure the heat produced is not absorbed by the surrounding body of the stove. This helps to direct most of the heat produced towards the cooking pot. This stove is constructed from clay/anthill or subsoil mixed with sand or silt.

This mixture is a very good conductor of heat. When we light a fire, much of the heat goes to heating the mass of the soil mixture that the stove is made up of. This means a lot of heat is absorbed by the stove itself, instead of being directed to the pot.

Why is this so?
In science we leam that heat travels trom a higher heat concentration to a lower heat concentration. This means when we make a fire, the heat passage or combustion chamber is very hot. However, the clay and sand mixture of the stove and the ground on which it rests are colder. So heat from the fire is absorbed into the stove and ground, leaving little to reach the cooking pot.

New innovation: Introduce an insulated material around the combustion chamber
As show in Fig. 5. above, the rocket arm from the firewood shelf to the cooking pot and all around it should be constructed with material that does not absorb heat. The more heat resistant the material, the more effective and efficient the stove will be. This means that the heat produced from the burning gases of the wood are not absorbed by the stoves body, but instead reached the cooking pot.

What makes this material resistant to heat?
The insulation material works on one major secret; it has a lot of air pockets in it. Air resists heat, it is a very poor heat conductor.

Local materials to use

a) The best local material that has been tested so far is pumice. This is a light volcanic rock common in Bufumbira, Kigezi and same parts of Bunyaruguru in Bushenyi district.

b) Sawdust, which is commonly found with carpenters or in saw mills. It is better to use very fine sawdust than course sawdust.

c) Vermiculite is fairly common rock that can be mined and crushed.

Here are so me simple instructions on how to construct a rocket-Lorena stove. We shall use sawdust in this example, since it is available in many parts of Uganda:

First prepare the clay mixture of clay and sawdust. The ratio should be 1:1

Clay *Sawdust*

Fig. 5.y

- Mix some water into the clay and sawdust. This forms the clay mixture. You can determine how strong your clay mixture is by rolling a piece of the mixture and seeing how easily it breaks.

If it breaks easily, there is too much sawdust

If does not break easily, there is too much clay

If it bends over and then breaks, the mixture is good

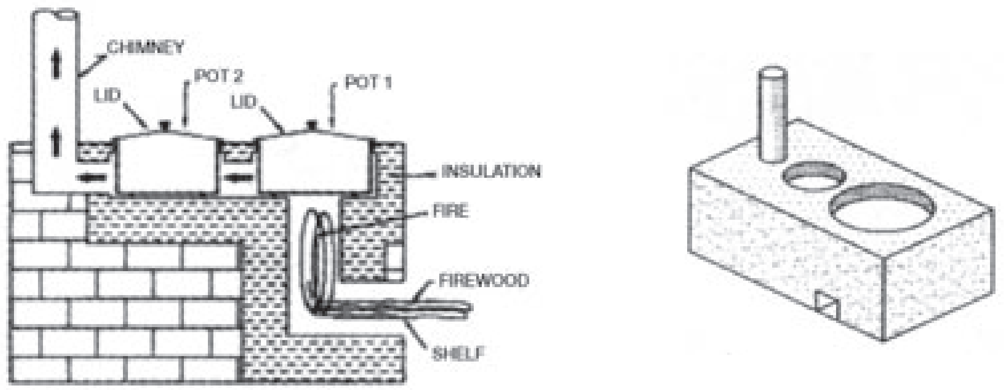
Fig. 5.z

- Choose 2 cooking pots that are used most in the kitchen. Line them up where you will construct the stove, separating them by a distance of your palm‘s width. Line them in order of the pot that needs the most heat, to that which needs the least heat.

Fig. 5.aa

- Make a map of the area the stove will cover, leaving an allowance for the chimney. The firebox should be opposite the door entrance, so that wind coming through the door helps to light up the fire.
- Dig a small trench for the foundation of the stove, and lay a few bricks or stones in the trench.
- Place bricks or pie ces of timber to mark out the area where the combustion chamber will be. This should be directly below that saucepan that requires a lot of heat. Place the timber like an arm bent at 90 degrees at the elbow, as shown in Fig. 5.bb.
- On top of the foundation, pile up the clay mixture to a desirable height. Level and smoothen the top of the pile.
- Get the two or three pots that you used at the beginning to make a map of the stove, and outline where they will rest on top of the clay mixture. These will make your pot rests. Also outline the position of the chimney.
- Dig out the clay in the area where your pots will rest until the entire pot is resting in the hole. Leave little space around the pot. Only the seam and cover of the pot should remain above the stove when cooking. This ensures that most of the surface area of the pot is exposed to heat, so that the food can cook faster. You can smoothen the area by wetting the sides of the pots rests, and twisting the pots until they fit comfortably.

○ Remove the timber and smooth out the tunnel, to connect the first pot rest to the second pot rest. Scoop a tunnel trom the second pot rest to the chimney. Construct the chimney using the same clay mixture as the rest ot the stove. The chimney should be 10 cm wide and 1.5 ft long and should lead the smoke out of the kitchen.



A cross section of the stove *The completed stove looks like this*

Fig. 5.bb: The Rocket-Lorena Stove

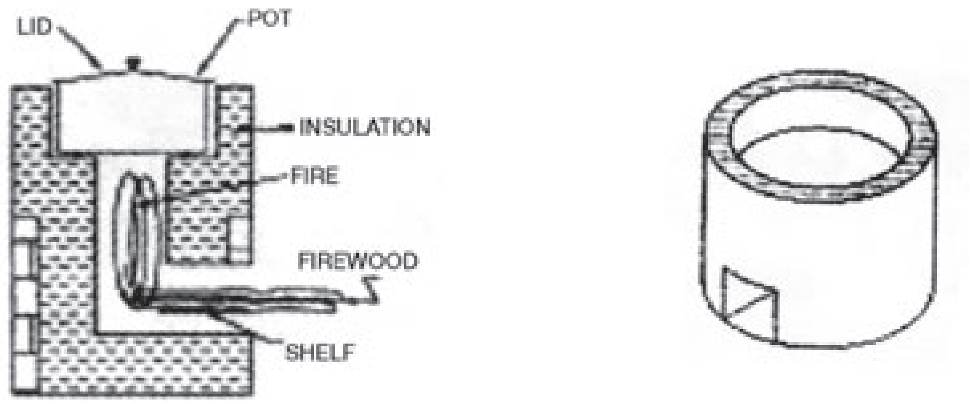
○ Leave the stove to dry for 4 weeks. For the first 3 days, continue twisting the saucepans in the pot rests to maintain the shape and size of the rests. Only start using the stove when it is completely dry.

○ After using the stove for some time, it may begin to develop some cracks. Repair these cracks with a clay and sawdust mixture. Also clean the chimney regularly with a flexible stick, to remove all soot that can block the airflow.

- **Shielded Three-Stone Fire**

This is an improved version of the traditional open fire, and has three openings to insert the pieces of wood. It still uses firewood, but this time less heat is lost because heat is directed to the cooking pot, and not lost to the surroundings.

The shielded three-stone fire is built on the same three outstanding principles that build the rocket-Lorena stove. as we leamt earlier, and is iIlustrated below:



A cross section of the stove *The completed stove looks like this*

Fig. 5.cc: The three-stone fire

When making the shielded three-stone fire, you should make the hole big enough to hold the biggest cooking pot in the kitchen. Make sure there is a space of about two centimetres around the saucepan. Any smaller pots can also be used on this stove.

- **Jiko (Metal and Clay Stove)**

This stove is an improvement of the *sigiri*, because it does not release a lot of heat. It is mainly made up of clay, but has a metallic lining on the outside.

Fig. 5. dd: The Jiko (metal and clay stove)

- **All-Ceramic Stove**

This stove is made of only clay mixture, it has no metal lining on the outside. It keeps heat very well because clay is a good insulator of heat. However, this stove is not as durable as the Jiko, because the clay cracks easily

Fig. 5. ee: The all-ceramic stove

From the above descriptions of energy efficient technologies, there are some important factors one should always consider:

❖ The firewood or charcoal used in the stoves should be well prepared. In order to get maximum heat from fuelwood, it must be very dry. This is why trees that dry quickly, such as the eucalyptus tree, are said to be better for fuelwood. When you are sure that the firewood is dry, cut it into short pieces that you can easily feed into the stove. Charcoal is made by burning wood without air, this process is called **carbonisation**. Well-prepared charcoal should be dry and well carbonised.

❖ There should be a good flow of air in the stove, to enable the fire to burn well. As we learnt earlier in the Chapter, it is not firewood that produces fire. Wood contains certain gases that it absorbs during photosynthesis, are released at about 250 degrees Celsius and start to burn in the air. This is why when you look at a piece of burning wood, the red, orange or blue flames form a few millimetres above the wood itself. If there is a good flow of air in the stove, then it will be easy for these gases to burn. However, too much wind will blow the fire out.

❖ The material used to make the stove should be a good insulator of heat. For example, clay is a better insulator than metal because it traps heat within the stove, whereas metal simply releases heat to the surroundings.

❖ Lastly, you should remember these simple cooking tips to make the process of cooking easier and faster.

  – Wash and cut up the food you are going to cook. Cut the food in small pieces because they cook faster than big pieces.
  – Soak dry foods overnight (such as dried peas and beans), so that they become soft and boil faster.
  – Only light the fire when you are ready to start cooking.
  – Use a saucepan that‘s just big enough for the dish you will cook. If the pan is too big it will waste a lot of heat energy.
  – Cover the food when you are cooking, so that the heat remains within the saucepan.
  – Do not cook outside if there is too much wind.

• **The Fireless Cooker or Hay Box Cooker**

This is an energy conservation technology that cooks food without fire. The fireless cooker is able to maintain the heat, and after a few hours the food will be well-cooked. This cooker is iIlustrated below in Fig. 5.ff.

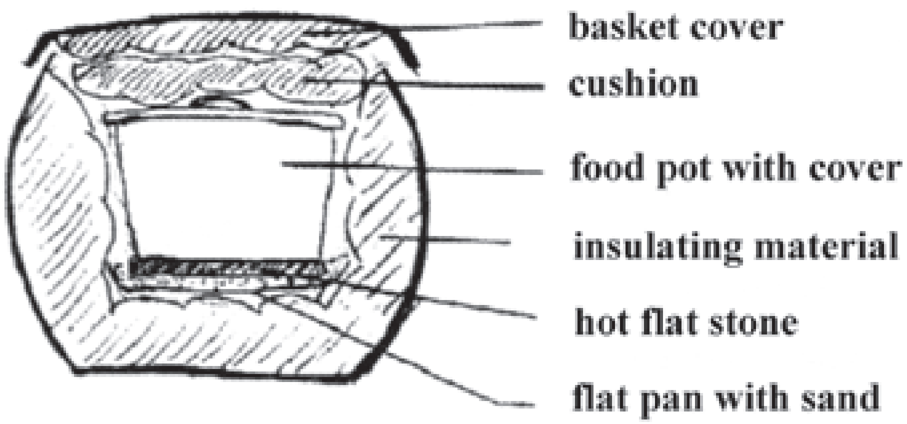


Fig. 5.ff

Here are some simple instructions on how to make a fireless cooker:

Fig. 5.gg:

1. Put the insulation material into the bottom of the basket, to about 8-10 cm high

Fig. 5.hh

2. Put your cooking pot on a large piece of heavy cloth or sacking

Fig. 5. ii

3. Pull the cloth over the pot, so that the pot is wrapped in the cloth

Fig. 5.kk

5. Pull the cloth away from the top of the pot. The edges of the cloth should touch the edges of the basket.

Fig. 5.mm

7. Sew so me cloth into a round bag that is big enough to fit over the cooking pot. Fill the bag with insulation material and sew up the top. This makes a cushion to cover the pot.

Fig. 5.jj

4. Put the wrapped cooking pot in the basket, on top of the insulation layer. Put more insulation around the wrapped pot, right up to the top of the pot. Pack it tightly with insulation.

Fig. 5.ll

6. Remove the pot, and sew the cloth to the sides of the basket.

Fig. 5.nn

8. Make another cushion that fits inside the basket cover. Sew it onto the basket cover.

The hay box cooker can be used to make soup, stew, beans, and other foods that cook for a long time. The hay box cooks slowly, so you need to leave food in it overnight, or during the day while you are at school. To use the hay box cooker, place a flat stone in a fire to make it very hot. Then prepare your food and leave it to boil in a pot for a while. When the stone is very hot, put it on same sand at the bottom of the hay box cooker. The sand will protect the cloth trom being burnt. The boiling food is then place on top of the hot stone, and quickly covered with the cushion and the basket-lid. Most foods will be ready within four hours.

iii. Biogas

This is an inflammable gas (a gas which easily catches fire) that is made from biomass. This biomass may be grasses, straw, husks and other crop residues, livestock manure, poultry manure, or human manure. The biomass is sealed in an airtight container or tank, and bacteria breaks down the plant and animal materials without using air. This process is called anaerobic digestion. As the biomass rots it produces a gas. This gas is composed of 60% methane and 40% carbon dioxide. However, it is methane gas that is called biogas. It has a strong odour, and burns with a blue flame.

Biogas can be used to cook food, or it may even be converted into electricity to use in your homes and schools. Biogas is made in biogas digesters. Let us look at three common types of biogas digesters.

- **Fixed Dome Digester**

This digester is also known as the Chinese type, and is illustrated in Fig. 5.oo below. It is very strong and used in many large-scale biogas plants. This digester is expensive to install, but is not expensive to maintain afterwards

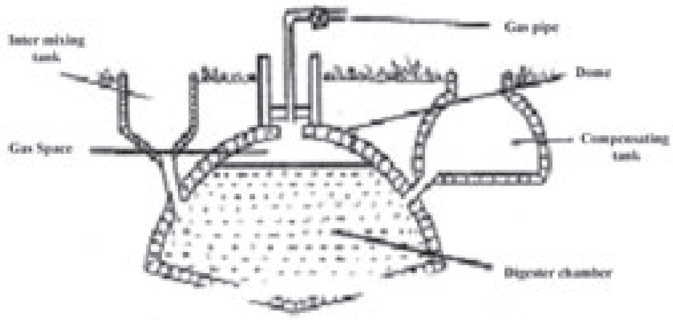


Fig. 5.oo: The fixed dome digester

- **Floating Drum Digester**

This is also known as the Indian type of digester, as is shown below in Fig. 5.pp. It is also expensive to install like the fixed dome digester. It is not recommended for swampy areas, because the drum may easily rust.

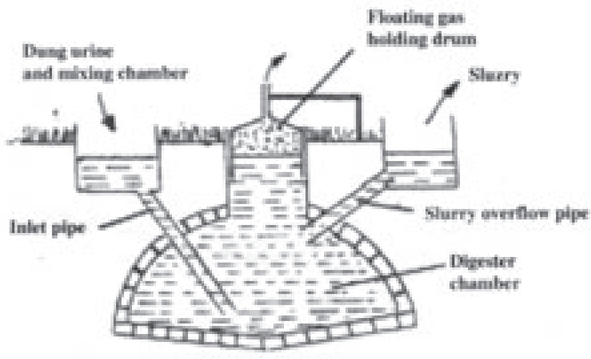


Fig. 5.pp: The floating drum digester

- **Tabular Plastic Bio-Digester (TPB)**

This is also known as a balloon digester (Fig. 5.qq). A tough balloon or polyethylene bag is used to hold the slurry and collect the biogas. It is much cheaper to install than those digesters described above.

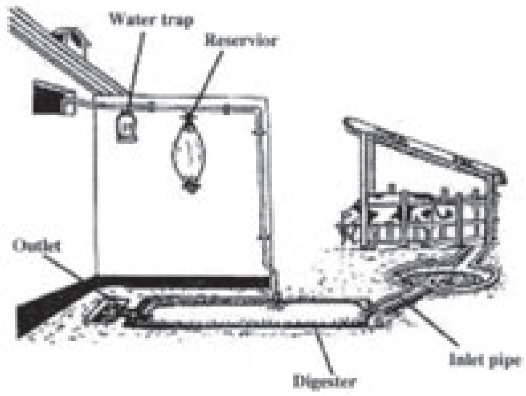


Fig 5.qq: The tabular plastic bio-digester

Biogas has several advantages over other sources of energy:

- ❖ It is environmentally friendly, because it is made from materials that do not cause pollution.
- ❖ It is a clean gas, because the rotting biomass is kept in a well-sealed container or tank. This also keeps away flies, mosquitoes and other harmful insects and animals. Biogas is also clean because it does not produce smoke, which is harmful to our lungs and eyes.
- ❖ It is cheap, because crop and animals residues can be got free. Especially if you have a farm at school or at home, or even from pit latrines.
- ❖ It has a by-product which can be used as organic manure, to fertilise fishponds, or to grow mushrooms. This by-product is the liquid or solid remains from the biomass, after the gas has been released. It is also called slurry.
- ❖ Someone can earn an income from setting up biogas technologies for other people, or selling biogas to other people.

In spite of its many advantages, biogas is not commonly used in Uganda. First, it requires qualified technicians to set up the biogas digester. Secondly, it requires large amounts of crop or animal residues, which may not be available in small homes. Lastly, the production of biogas offends some cultures, especially when human manure from pit latrines is used to create biogas.

Here are some tips on having a successful domestic biogas plant:

- *Every member of the family should know how the gas is generated and which precautionary measures must be taken.*
- *Check every day personally to make sure every thing is going on well. Feed the digester once at least every day.*
- *Keep the digester and reservoir away from the sun's direct heat.*
- *Fence the digester and reservoir off children and stray animals and intruders.*
- *Do not use contaminated water such as with soap.*
- *Never throw grass, sand or glass into the digester.*
- *Make sure when using the gas, press the gas reservoir down with some weight (2-5 kg).*
- *Remove slurry everyday (1-2 litres off).*
- *The water trap must always be full.*

5.5 Tips on Conserving Energy

Conservation or preparing only what we really need is a new concept in most cultures in Uganda. When we cook lunch for a family of five, we prepare food for eight people in case visitors come. For dinner we cook the same amount to make sure there are some leftovers for breakfast. It is common to find a family sitting around a bright fire at night talking. The paraffin lamp is also burning, but is overshadowed by the bright fire. This is a waste of paraffin, which is very costly to an average family in the village. We therefore need to build a new culture of energy conservation in Uganda. The best target group to influence while still young are primary school children. This section will outline some tips we can practice to save energy.

5.5.1 Soak hard dry foods before cooking

The purpose of cooking food is to make it softer and make it easier to chew and swallow. It also improves the taste. However, too much time and firewood is wasted on cooking dry things such as beans, peas, dry fish and dry meat when they are still hard. Many families, even in areas with little firewood, do not soak beans. Many schools cook up to 100 kilograms of beans daily but do not soak the beans. Most of the firewood is wasted on cooking beans.

Soak the beans overnight, or for at least three to four hours before cooking. The beans will cook in half the time you would use if they were dry. It is like cooking fresh beans. This way you use less firewood also.

5.5.2 Cover the cooking pot when cooking

When we cook food, the main medium of transferring heat to the food being cooked is water. Water boils at 100 degrees Celsius then starts evaporating. When the water evaporates it is wasted energy. Even some of the minerals and vitamins evaporate in the water and are lost to the surrounding air, instead of remaining in the food.

Cover the cooking pot when you are cooking. This helps in three ways:

i. The cover or lid pushes the evaporating steam back into the food. The heat is kept in the pot and helps to cook the food faster. Even when boiling water or milk, cover the saucepan. The water or milk will boil in about half the time than when it is not covered.

ii. You will use less water because both the water and heat in form of steam are being recycled back into the pot.

iii. The vitamins and mineral salts in the steam will go back into the food.

5.5.3 Avoid adding too much water when cooking

When we cook beans or bananas, the cooking takes place when water reaches its boiling point of 100 degrees Celsius. If you add too much firewood, the food will not cook any faster. Instead you will be evaporating the water in the saucepan. When the water in the beans or bananas gets dry, you then add cold water. The cooking will immediately stop until the cold water you added starts to boil again.

i. *Do not put too much firewood when the water starts boiling. Leave just enough heat to keep the water boiling. Too much firewood will evaporate the hot water quickly which you need to cook your food.*
ii. *When water is dry in the food you are cooking add only a little more water to keep the food boiling. Too much cold water will cook down the food and the cooking process will stop until the cold water you added starts boiling again.*

5.5.4 Use only very dry firewood

When cooks in three schools were interviewed, they all said that if you use dry firewood, the wood gets finished quickly and does not cook food properly, and that there is need to mix dry and moist firewood in order for the firewood to last longer. This is wrong and wasteful cooking.

*Wet firewood does not burn. For firewood to burn, it must be dry. So when you use wet firewood, 50% of the heat energy produced first goes to dry up the firewood so that it can burn. This is a slow process through which a lot of energy is wasted. At the same time, the gases from the wood mix with water vapour. This cools the gases and they do not burn properly. When there are unburnt gases in the wood, it forms what we call **smoke**. Smoke is unburnt gases that were meant to burn and make a strong fire. Smoke, therefore, is wasted fire; it is wasted energy.*

5.5.5 Other General Tips on Conserving Energy

Only by practising and preaching conservation tips can we think of conserving energy. Good habits taught early, such as those we are about to leam, will help us to fight the energy crisis before it gets too late.

At Home

- Switch off lights and fans in the rooms that are not occupied.
- Use tube lamps instead of the round incandescent 60, 75 or 100-watt bulbs which waste energy in form of heat. Tube (fluorescent) lamps may be expensive but they last a very long time, and use less electricity than the round bulbs.
- You would rather mix warm water in a bucket than use a shower. Showers take a lot of power and can use up to 90 litres of water tor each bath!

- If you must boil your water with any kind of water boiler, change the heat element every five years. The new element heats faster and so saves energy.
- When ironing, plug the iron in only when you have all your clothes ready and nearby.
- If you have tube lights that use traditional chokes, replace them with electronic chokes and you will save up to ¾ of the energy that would have been lost.
- Use light colours on your walls because they help reduce the lighting requirements by up to 40%.
- Clean your tubes regularly. Do not keep your lights dirty as dirt reduces lighting levels by as much as 30%.
- Clean and lubricate your fans regularly as this helps reduce electricity consumption.
- If you have a fridge, cool the food properly before storing it. Avoid putting hot things in the fridge before they have cooled. Make sure the fridge door locks well and avoid opening the door frequently.

In the Kitchen

- Try to use pressure cookers. They save a lot ot energy. It the water has boiled, reduce the flame or reduce the firewood. If you are using charcoal, do not leave the stove door completely open.
- Prepare everything before you light the fire. 00 not light the fire then begin to wash sauce-pans.
- As a family, try to eat together so as to avoid repeated warming of food.

The Transport Sector

- Plan your trips properly in such a way that you avoid wasteful driving.
- Whenever possible and convenient, use public transport other than a personal vehicle.
- If you have a motorbike or the car when more people or heavy luggage is to be transported.
- A lot of fuel is wasted in traffic jams. Following traffic signals will help avoid such wasteful jams.
- Try as much as possible to avoid idling your car or motorbike.
- Service and tune your vehicle regularly. It helps in efficient fuel consumption.
- Use high quality lubricants. Never compromise this.
- Correct driving habits are very important in conserving energy. Avoid sudden over-speeding, overloading, sudden braking and so on.

The Industrial Sector

- Waste heat energy recovery systems must be put in place while alternative sources of energy must be sought.
- Running motors in industries accounts for over 70% of electric energy used. To reduce on energy loss, these motors must run at the rated voltage and be maintained regularly.

- Industries must try to improve on their existing systems of equipment and increase efficiency.
- Attention should move from existing sources of energy to new renewable sources. For example, the sugar industry should turn to using the leftovers after the sugarcanes have been crushed to generate power; these leftovers are called bagasse.
- Low-pressure sodium lamps are the most efficient artificial lighting with a long service life. They maintain their light output better than any other lamp type. Industries should use these for security outdoor lighting.

Summary of "Energy Conservation Technologies"

In this Chapter we have covered the following:

1. The meaning of energy conservation and energy conservation technologies
2. Several energy conservation technologies for different sources of energy
3. How to make some of the energy conservation technologies learnt
4. Tips on how to conserve different sources of energy.

Only through practicing **energy conservation** can we be sure that there will be energy for future generations!

CHAPTER 6

ENERGY AND THE ENVIRONMENT

Objectives:

- *To explain how the production and use of the different sources of energy affect the environment.*

6.1 Introduction

Now that we have learnt the importance of energy in our lives, and how to use energy sustainably, we must also study the outcomes that using energy can bring. As we use the different sources of energy, we may be causing some harmful effects on our **environment**, or our surroundings. In this chapter, we shall look at how the use of energy can be harmful to our environment. and how we can reduce this damage to our environment.

6.2 Biomass Energy and the Environment

In Uganda. the greatest source of energy is biomass extracted from our natural forests. This means that large areas of forest are cut down to get trees for firewood and charcoal. The act of cutting down trees in a forest is called **deforestation**. Once our forests are destroyed, many more problems will arise. For example, certain animals like monkeys, gorillas, birds and snakes that live in the forests will no longer have a home, or a habitat (Fig. 6.a).

Fig. 6.a: Animals fleeing as trees are cut down

If we cut down trees we will also leave our land bare. This will lead to soil erosion, reduced soil fertility and smaller crop yields. Less food will be produced, so we shall have less food to eat.

However, the greatest harm of deforestation in the world today is global warming. This occurs when heat-trapping gases, such as carbon dioxide, are in excessive amounts in the atmosphere. These gases will continue to trap the sun‘s heat on earth, instead of releasing it back into space. And this in turn leads to a rise in temperatures around the globe. This process is referred to as **global warming**.

The presence of forests can control global warming, because the plants absorb the excess carbon dioxide. But when forests have been cut down for firewood, there will be no trees to absorb the heat-trapping carbon dioxide, and temperatures will continue to rise around the planet.

Another negative effect of using biomass comes from the danger of fuelwood-burning stoves, both indoors and outdoors. This is a particular danger to people, because burning firewood or charcoal will release some tiny particles (such as ash and dust), as well as a harmful gas called carbon monoxide (Fig. 6.b). We can have health problems such as heart disease, lung disease, or dizziness when we breathe in too much carbon monoxide. This gas is also harmful to the babies that pregnant mothers are carrying.

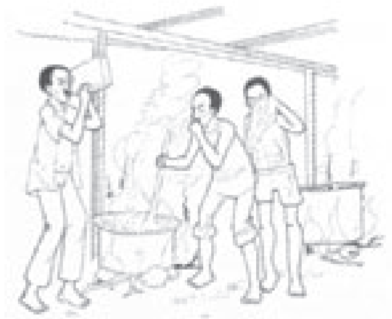


Fig. 6.b: Cooks disturbed by heat, gases and ash from an open fire

6.3 Fossil Fuels and the Environment

Fossil fuels such as diesel, petrol and paraffin, are harmful to the environment when they are burnt for energy. This is because they release fumes or smoke with dangerous gases. These gases can directly affect people‘s health by causing lung disease, heart disease, and even eye problems.

Fossil fuels also harm the environment by releasing heat-trapping gases as we had described above. Fossil fuels are in fact the greatest cause of global warming in the world today, because when they are burnt for energy they release harmful gases such as carbon dioxide, sulphur dioxide, and nitrous oxides. All these pollute the environment and cause **global warming**.

Fossil fuels are also harmful because they release acids into the atmosphere, which combine with moisture to form acid rain. When fossil fuels are burnt, they give off sulphur dioxide and nitrous oxides into the atmosphere. These acids eventually mix with the moisture and come back to earth in the form of acid rain. Acid rain is very dangerous because it can burn down plants, and even the skin of human beings and animals. Acid rain is so harsh to any surface that it can erode the surfaces of marble buildings. This takes place in many developed countries in Europe, and also in the USA, where there are very many cars, lorries and large industries that all use fossil fuels. They therefore throw a lot of fumes and smoke into the atmosphere. When it rains, the rainwater mixes with these gases in the sky, and fall to the earth as acid rain.

Petroleum in particular is a problem to the environment during its exploration and transportation. When **oil spills** occur, huge amounts of oil cover the surface of seas, lakes, or even land. This means that all the living things that had a home in these areas will be covered by the oil, and die from suffocation. For example, when a ship carrying petroleum overturns in an ocean or lake, the fish and sea animals in that area die. Even here in Uganda, when a tanker lorry carrying diesel or fuel overturn, our rivers and water wells get covered by it, and we cannot drink that water. If cows and goats drink such water, they also die.

6.4 Nuclear Energy and the Environment

This form of energy is very harmful to the health of people, because it releases chemicals that are extremely harmful for any form of life. These chemicals can affect very many parts of our bodies, and the natural growth of human beings. Even a baby that is still in its mother‘s womb can be born malformed or mentally disturbed, if nuclear chemicals affect its mother. This has happened in Japan, which was hit by a nuclear bomb during the Second World War. In Russia in the 1950s, when a nuclear reactor or plant for producing electricity got damaged and leaked, many people and animals died.

6.5 Hydropower and the Environment

Although hydropower has been discovered to be a clean source of energy, without environmental pollution, the impact of creating dams on the surrounding areas can still be harmful. When dams are created at hydropower stations, they hold back silt, debris and vital nutrients. This means that silt will accumulate on the dam‘s floor, and toxic heavy metals and other pollutants in the silt will also pile up. These pollutants are a danger to fish, papyrus and any other aquatic life (things that live in water).

These pollutants can even be drunk or bathed in by nearby communities who fetch water from the dam, thereby affecting their health. This could lead to infections such as the bilharzias worm infection.

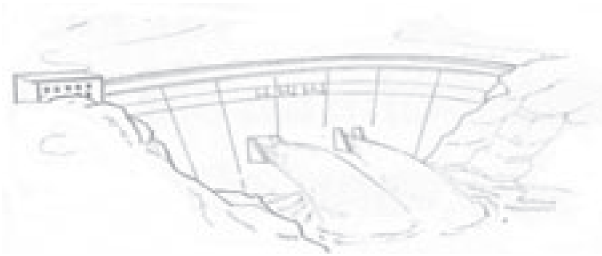


Fig. 6.c: A hydropower dam

Dams will also cause problems for future generations who may want to use the area. The accumulated silt is a mess that is dangerous and expensive for future generations to clean up. In addition, the dams also flood good and fertile land that people were using as agricultural land. All the plants and other small animals covered by the dam‘s water die, and the area changes completely.

More importantly, for nature lovers and environmentalists, dams spoil the natural beauty of the area. For example, at Owen Falls Dam in Jinja, there used to be a beautiful natural waterfall, which view has now been covered by the dam. On the beautiful Bujagali Falls, the construction of a hydroelectric dam has been proposed. Future generations may never see for themselves the natural beauty of the Bujagali Falls if this dam is built.

6.6 Solar Energy, Wind Energy, Geothermal Energy and the Environment

These three forms of energy are less harmful to the environment, and are often referred to as „clean and green“ sources of energy. This implies that they do not have many negative impacts on the environment. However, it is important to remember climatic factors when deciding which source of energy to exploit. For example, in order to exploit solar energy you must be sure that the area where you establish the power plants receives plenty of sunshine. Without enough sunshine, the photovoltaic (PV) cells would not function. Likewise, without enough wind, wind energy cannot be exploited to make the windmills turn.

The problem arises, however, when the items used for solar energy grow old and have to be thrown away and replaced by new ones. The battery used in solar electricity has to be thrown away every two to five years, and the PV cells must be replaced every 25 years on average (Fig. 6.d). The remains that are thrown away are dangerous to the environment, because they are not easily degradable (they do not ‚rot‘ easily).

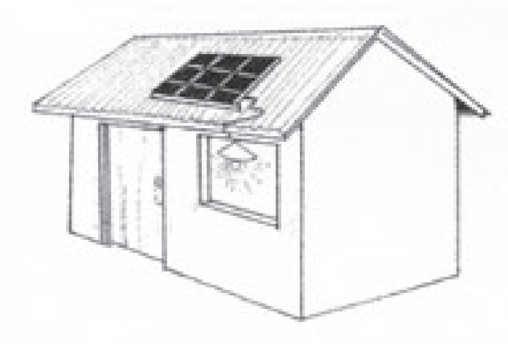


Fig. 6.d: A house lit by solar energy

Geothermal energy also impacts on the environment. Heat released from the earth‘s crust comes with very strong, offensive smelling gases such as sulphur. This smell can irritate people and other animals in the surroundings.

Summary of "Energy and the Environment"

In this Chapter we have covered the following:

1. How producing or capturing energy affects the environment
2. How the use of different energy sources affects the environment.

Although energy is a very important part of our lives, it can negatively affect our health and our environment.

<u>We must minimise the negative impacts of energy production and energy use on our environment.</u>

ENERGY IS LIFE

A Resource Book on Sustainable Energy Use

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TEACHER‘S GUIDE TO PUPILS‘ WORKBOOK

Introduction

After discussing thc concepts, examples and new vocabulary in Chapter One, give the children the following activities. The activities may be done individually, or in groups. Activities that require practical skills will necessitate the teacher‘s guidance throughout the duration of the activity.

Each activity in this guide is arranged under the following topics:

- **Section**: This shows the section within the chapter of the Manual, from which the activity is derived
- **Page**: This shows thc page number where the section is found in the Manual.
- **Equipment/Tools**: This lists all the stationery, scientific instruments, agricultural equipment, materials, and any other tools that are needed to carry out the activity.
- **Time**: This indicates the recommended time within which the activity should be performed by the pupils.
- **Skills**: This outlines the skills that the pupils are expected to use and enhance during the activity, such as critical thinking, graphing, vocabulary and practical skills.
- **Procedure**: This further describes the process of carrying out the activity. It is a supplement to the instructions given in the workbook, where necessary.

CHAPTER ONE

UNDERSTANDING ENERGY

Activity	**Section**	**Page**	**Equipment / Tools**	**Time (minutes)**	**Skills**	**Procedure**
1. Energy news time	1.1	1	• Pupil's workbooks • Blank paper to make notes • A pen or pencil • A radio or a box	30	• Critical thinking • Vocabulary • Presentation	– Give each group of students 20 minutes to prepare their Energy news Bulletin. – Each presentation of the bulletin should last no more than 10 minutes
2. Describe the illustrations	1.3	4	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
3. Describe the illustrations	1.3, 1.4	4,7	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*

CHAPTER TWO

TYPES AND FORMS OF ENERGY

Activity	**Section**	**Page**	**Equipment / Tools**	**Time (minutes)**	**Skills**	**Procedure**
1. Fill in the gaps	2.1, 2.2	9,10	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
2. Describe the illustrations	2.1	9	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
3. Making a fire using solar rays	2.2.1	12	• Piece of curved glass or magnifying glass • Sheet of paper	20	• Practical	– Place the sheet of paper on a stool or table, direct the sun‘s rays to the paper, using the piece of glass; IMPORTANT: If you use a piece of curved glass, make sure the children handle it well, to avoid accidents.
4. Heating rods	2.2.2	12	• Pupil's workbooks • A pen or pencil • A sigiri • A saucepan with water • A wooden spoon • A stick • A metal spoon • A plastic pen	30	• Practical	*As in workbook*

Activity	Section	Page	Equipment / Tools	Time (minutes)	Skills	Procedure
5. Describe the illustrations	2.2.3	7	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
6. Brain teaser	2.2.4	8	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
7. Lighting a bulb with electricity	2.2.5	8	• Pupil's workbooks • A pen or pencil • A battery • An electric bulb • A wire	20	• Practical	*As in workbook*
8. Sound energy in a drum	2.2.6	8	• Pupil's workbooks • A pen or pencil • A drum • A coin	15	• Practical	*As in workbook*
9. Brain teaser	2.2.7	9	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
10. Magnetic fields I	2.2.8	9	• Pupil's workbooks • A pen or pencil	15	• Practical	*As in workbook*
11. Magnetic fields II	2.2.8	9	• Pupil's workbooks • A pen or pencil • Razor blade • Nail for building • Fork • Saucepan • Piece of jewellery	15	• Practical	– Hold the magnet a few centimetres above the objects. – Slowly bring the magnet closer to the object, until the magnet pulls the object towards itself.

CHAPTER THREE

SOURCES OF ENERGY

Activity	**Section**	**Page**	**Equipment / Tools**	**Time (minutes)**	**Skills**	**Procedure**
1. Brain teaser	3.1	10	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
2. Circle or square?	3.2, 3.3	10	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
3. Drawing a pie chart	3.2, 3.3	11	• Pupil's workbooks • A pen or pencil • A compass • A ruler	30	• Graphing / tabulating	*As in workbook*
4. Who am I?	3.2, 3.3	11	• Costumes	15	• Presentation	– Give the pupils 10 minutes to prepare themselves. – Allow each pupil to describe himself/herself for not more than five minutes, before another pupil is given a turn.

Activity	Section	Page	Equipment / Tools	Time (minutes)	Skills	Procedure
5. Drawing a bar graph	3.2, 3.3	12	• Pupil's workbooks • A pen or pencil • Colour pencils or crayons • A ruler	30	• Graphing	*As in workbook*
6. Fill in the gaps	3.2.1	13	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
7. Brain teaser	3.2.1	13	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary • Communication skills	*As in workbook*
8. Fill in the gaps	3.2.1	14	• Pupil's workbooks • A pen or pencil	10	• Critical thinking • Vocabulary • Communication skills	*As in workbook*
9. Mock debate	3.2.1	15	• Paper, pen or pencil for Secretary	35	• Presentation • Communication skills	– Allow each side to present their views for 10 minutes each. – Give the Debate Secretary 5 minutes to make a conclud-ing statement at the end of the debate.
10. A "food chain" short play	3.2.1	15	• Costumes	35	• Presentation	– Give the pupils 15 minutes to prepare their skit. – The pupils should present the skit in 20 minutes.
11. Fill in the gaps	3.2.2	16	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
12. True or false?	3.2.2	16	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*

Activity	Section	Page	Equipment / Tools	Time (minutes)	Skills	Procedure
13. Fill in the gaps	3.2.3	17	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
14. True or false?	3.2.4	17	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
15. Label and describe the illustration	3.2.5	18	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
16. Fill in the gaps	3.2.5	18	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
17. Matching game	3.2.5	19	• Pupil's workbooks • A pen or pencil • A ruler	15	• Critical thinking • Vocabulary	*As in workbook*
18. Matching game	3.2.5	19	• Pupil's workbooks • A pen or pencil • A ruler	15	• Critical thinking • Vocabulary	*As in workbook*
19. Brain teaser	3.3.1	20	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
20. Fill in the gaps	3.3	20	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
21. Label the diagram	3.3.1	20	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
22. Fill in the table	3.3.1	21	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
23. Label the parts of an atom	3.3.2	22	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
24. Fill in the gaps	3.3.2	22	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*

CHAPTER FOUR

THE PRODUCTION AND EFFICIENT USE OF ENERGY

Activity	**Section**	**Page**	**Equipment / Tools**	**Time (minutes)**	**Skills**	**Procedure**
1. Brain teaser	4.1	23	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
2. Drawing	4.5 A	23, 24	• Pupil's workbooks • A pen or pencil	15	• Practical	*As in workbook*
3. Setting up a backyard garden	4.5 A	25	• Manure • Local vegetables • A hoe • A watering can	-	• Practical	*As in resource book*
4. Brain teaser	4.5 B	26	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*

CHAPTER FIVE

ENERGY CONSERVATION TECHNOLOGIES

Activity	**Section**	**Page**	**Equipment / Tools**	**Time (minutes)**	**Skills**	**Procedure**
1. Do-it-yourself greenhouse	5.2.2	27	• A cardboard box • Scissors • A ruler • Sticky tape • A thermometer or leaf • A thin transparent plastic	35	• Critical thinking • Vocabulary	– Guide the pupilsl to take readings before and after placing the plastic cover on the greenhouse. – Let them reson out why the temperatures are higher with the plastic cover. – Explain the importance of the lessons learnt in relation to a real-life greenhouse.
2. Describe the illustrations	5.2.2	28	• Pupil's workbooks • A pen or pencil	20	• Critical thinking • Vocabulary	*As in workbook*
3. An outdoor game	5.3	29	• 10 drinking straws	30	• Critical thinking	*As in workbook*
4. Fill in the gaps	5.3	29	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
5. Matching game	5.3	30	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*

Activity	Section	Page	Equipment / Tools	Time (minutes)	Skills	Procedure
6. Establishing a tree nursery	5.3	30 - 32	• A piece of land e.g. school garden, community land • Hoe • Chosen seeds • Water and watering can • Sand • Manure • Poles and wire to fence off the nursery • Poles and dry papyrus for a shade • Plastic pots to transplant the seedlings	-	• Critical thinking • Vocabulary	*As in workbook*
7. Brain teaser	5.4 ii	33	• Wheel barow and spade to mix soil • Clay or subsoil • Sand or silt • Water, potato leaves • Bricks or stones • 2 or 3 saucepans • A banana stem	-	• Practical	*As in workbook*
8. Making a fireless cooker	5.4 ii	35	• Basket, insulating material • Large, flat stone	-	• Practical	*As in workbook*
9. Pair-up	5.4 iii	36	• Paper • A pen or pencil • A basket	30	• Critical thinking • Vocabulary • Creativity	*As in workbook*
10. Fill in the gaps	5.4 iii	36	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*
11. Matching game	5.4 iii	37	• Pupil's workbooks • A pen or pencil	15	• Critical thinking • Vocabulary	*As in workbook*