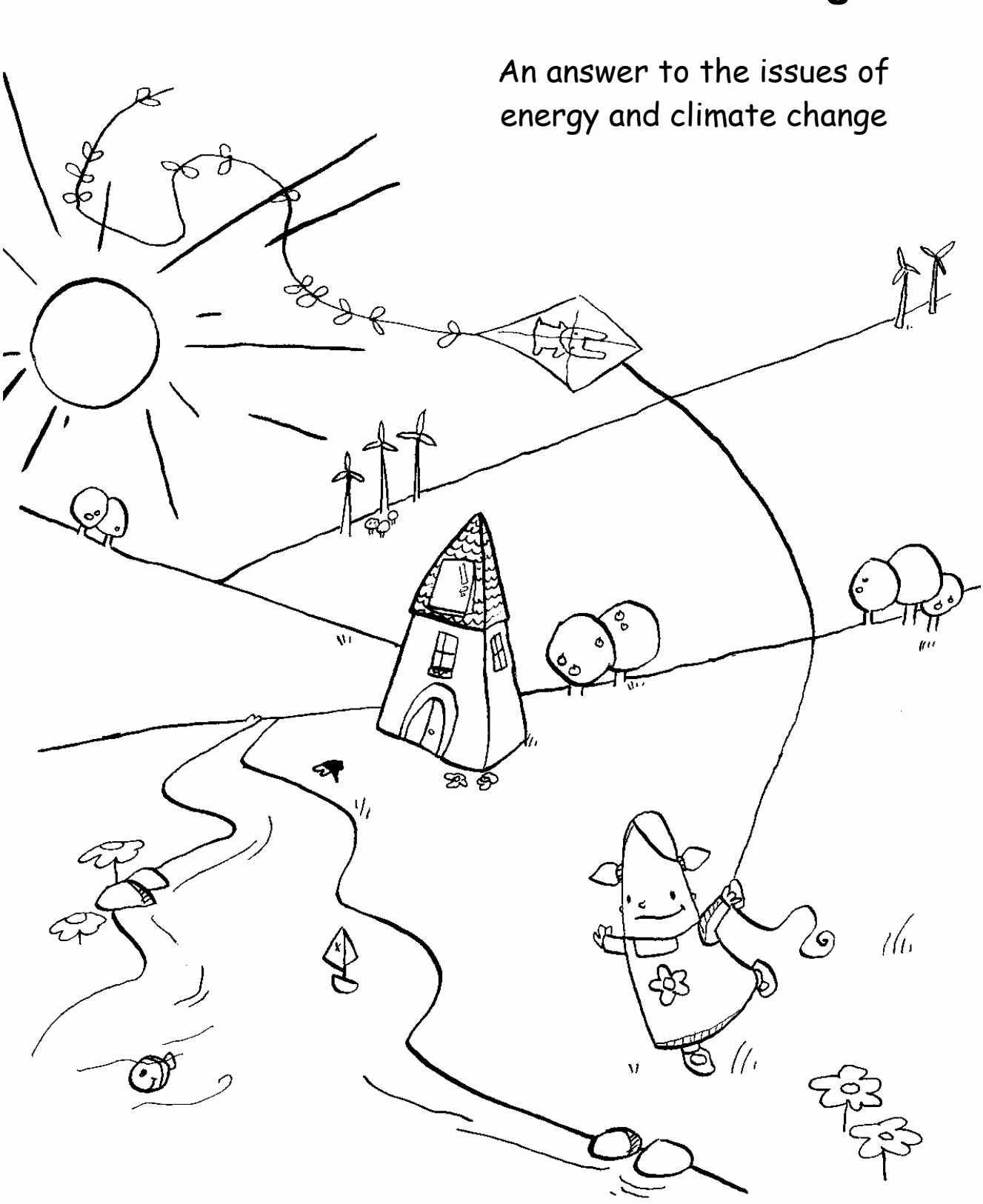
Renewable energies

An answer to the issues of energy and climate change



Teaching material for HELIOMOBILE presentations given by APERe, with the support of the Walloon Region- *7th March 2005*
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Contents

Renewable energies, an answer to the issues of energy and climate change.

The words followed by an * are defined in the glossary at the end of this publication.

Introduction

This reference material is proposed to teachers of basic education, as a support to our HELIOMOBILE presentations, which have been conducted in schools throughout Wallonia since 2001, funded by the Walloon Region.

By taking a technological approach to the subject of energy (solar water heater) during the presentation, we are able to explain the basic scientific principles of the technology. Through the questions & answers and debates initiated in the classroom, we are able to discuss various aspects of energy - historic, geographic, socio-economic, scientific, technological, philosophical and ethical –based on all of these subjects which are taught in both primary and secondary education.

This presentation material will be useful to prepare for our visit to the class, or to look in more detail at certain concepts introduced during the presentation.

Through a combined approach covering energy, the environment and society, to raise awareness of young people to the issues of energy and climate changes, we have attempted in writing this material to be faithful to the interdisciplinary nature of energy. Various points of view are proposed in it to consider energy and its various aspects transversally.

Four general questions are developed in this publication:

- What is energy?
- What are the sources most often used today?
- What are the problems related to energy consumption?
- What possible solutions exist to the problems related to energy use?

By offering answers to these questions, we hope to contribute to the education of the youngest people in choices open to the public, so that changes in behaviour to take root with regard to energy use and consumption.

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1. What is energy?

A concept which is not easy to understand:

When it comes to defining energy, we are often at a loss. We use energy every day. The television, the car, the telephone, our bike or heating the home all require a source of energy in order to operate. Even we have to eat a balanced diet in order to remain healthy.
But what actually is energy?

The definition we find in the Oxford dictionary is as follows: "the capacity of matter or radiation to do work". The notion of energy is therefore defined by its effects, which is a rather strange type of definition and not easy to grasp.

We could say, to be a little more clear, that energy is "what makes things work". Energy is what enables objects, machines*, plants, animals and humans to operate, grow, move, think, heat themselves, etc.

A common element between the sun, petrol and our sandwiches is therefore that they are sources of energy: the sun enables plants to grow, petrol enables our cars to run and our sandwiches enables us to remain attentive in the classroom all day long. They are energy sources.

We can therefore see that energy exists in many different forms. The difficulty with the notion of energy is that we can observe *the source* of the energy (petrol, the sun, food, etc.) or the *effect* produced by energy (a plant which grows, a machine which operates correctly, a bike which is moving, etc.) but we never see the *energy itself*.

The difference between energy source and form of energy:

A person's job, when they want to use energy, is to seek energy where it is found, at the energy source, and to transform it into a usable form.

1. The energy source is what is going to be used to provide energy. It may be matter (petrol, coal, sandwiches, etc.), radiation such as sunlight or a force like the wind or a river.

2. The form of energy is the form in which energy is presented to be used.

3. We speak of the useful effect of energy to describe the effect sought by using the energy. For example, the fact that our houses are warm even in winter is a useful effect of the energy used in our boilers. The growth of plants is the useful effect of using sunlight.

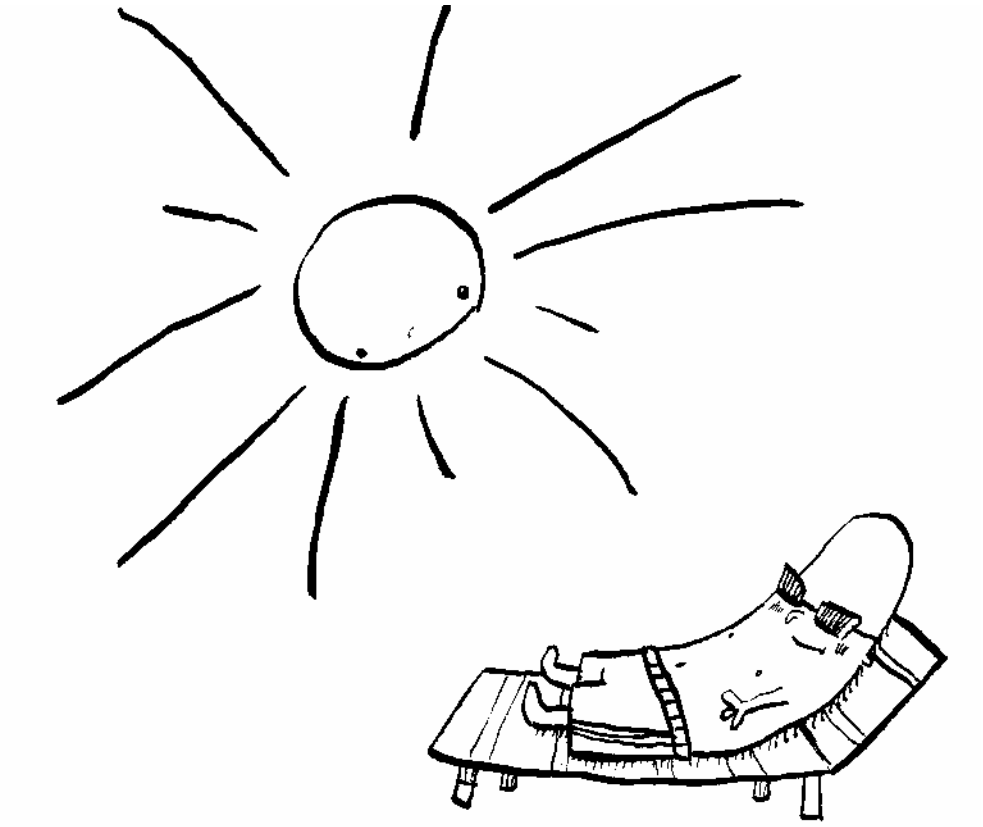
The source therefore provides us with energy, which is going to be used in a certain form, in order to produce a certain effect. There are several different forms of energies.

In a car for example, the source of energy is petrol or diesel, and the energy which they contain is used in a mechanical form, in order to make the car move. The engine burns petrol in order to be able to make the axle turn which turns the wheels.

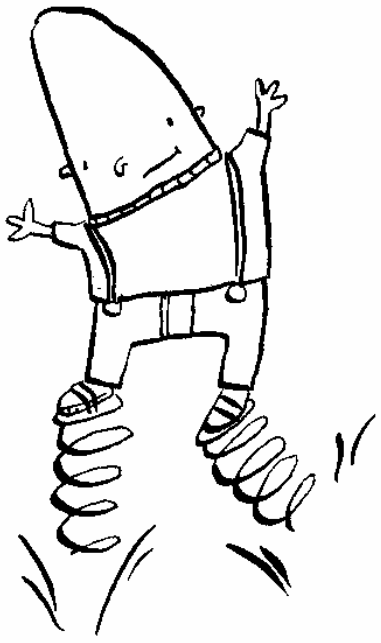
In order to explain the operation of machines in a little more depth and describe a little better the various steps involved in the transformation of energy, we are now going to discover the various forms of energy. We generally classify the forms of energy into seven different categories. Here is the most commonly accepted breakdown, although it is not the only one.

The seven different forms of energies:

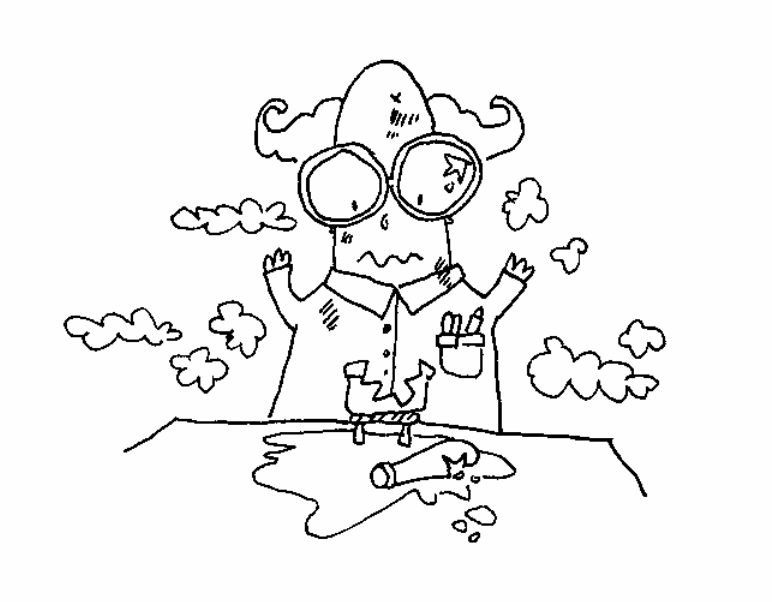
1. Energy in the form of radiation: this is energy which exists in rays (or "electromagnetic waves"*), such as light or even ultra-violets rays, infra-red rays, etc. This form of energy is in fact used widely in nature: without the sun and its light, there would be no life as we know it on the Earth. Plants need it to live and grow (in natural photosynthesis, as we have already said). Men and animals also need it for heat and the light provided by the rays of light.



2. Energy in <u>mechanical</u> form: this is the energy used to move solid, physical objects. All moving objects therefore possess mechanical energy. This energy turns the cogwheels in clocks, CDs in Hi-Fi systems or car wheels, but it is also stored in the springs of watches or wind-up toys. By winding up objects with springs, we store energy in these springs. This energy will be released to turn the wheels of toys.

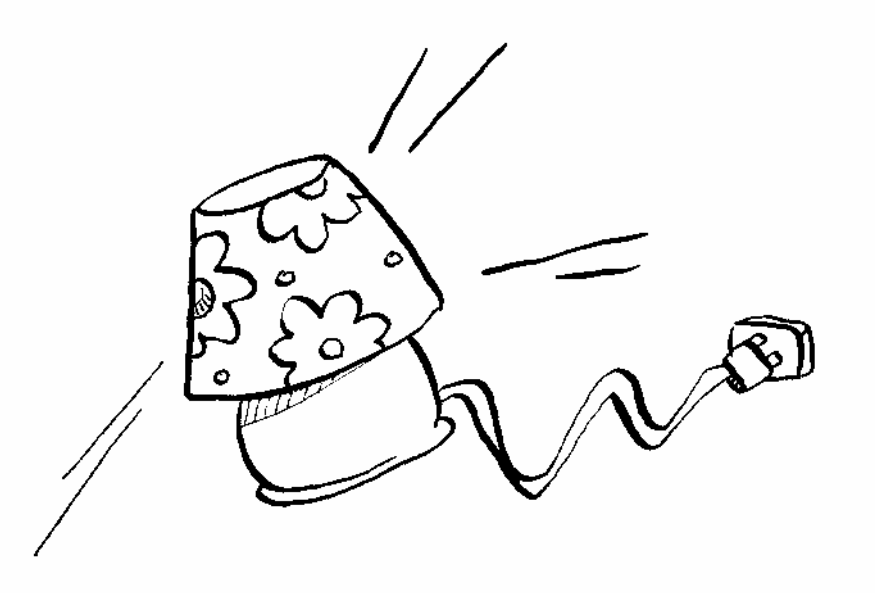


3. Energy in chemical form: This energy is stored in artificial chemical components, but also in natural products. When we eat and breathe, we are building up reserves of chemical energy in order to be able to live, move, run, ride a bicycle, read and study, etc. But plants also generate chemical energy from the sun and the nutrients they take from the soil and the air (this is called natural photosynthesis*). Electrical batteries provide electricity also produced through chemical reactions. On a more serious note, chemical energy is also present in dangerous, explosive products such as dynamite…

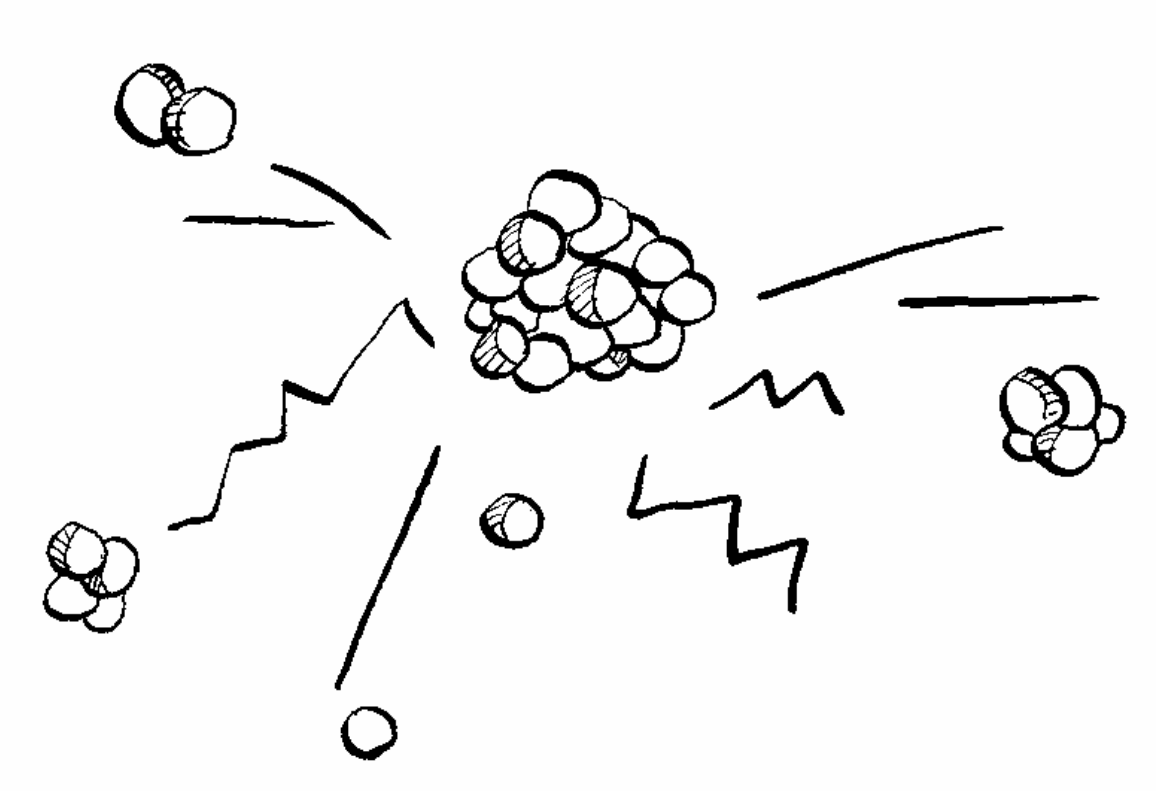


4. Energy in thermal form: this energy exists in the form of heat. It can be found in numerous sources, such as fire or oil or coal combustion*. When man learned to control fire, it probably brought about a huge change, which enabled him to improve his difficult living conditions.

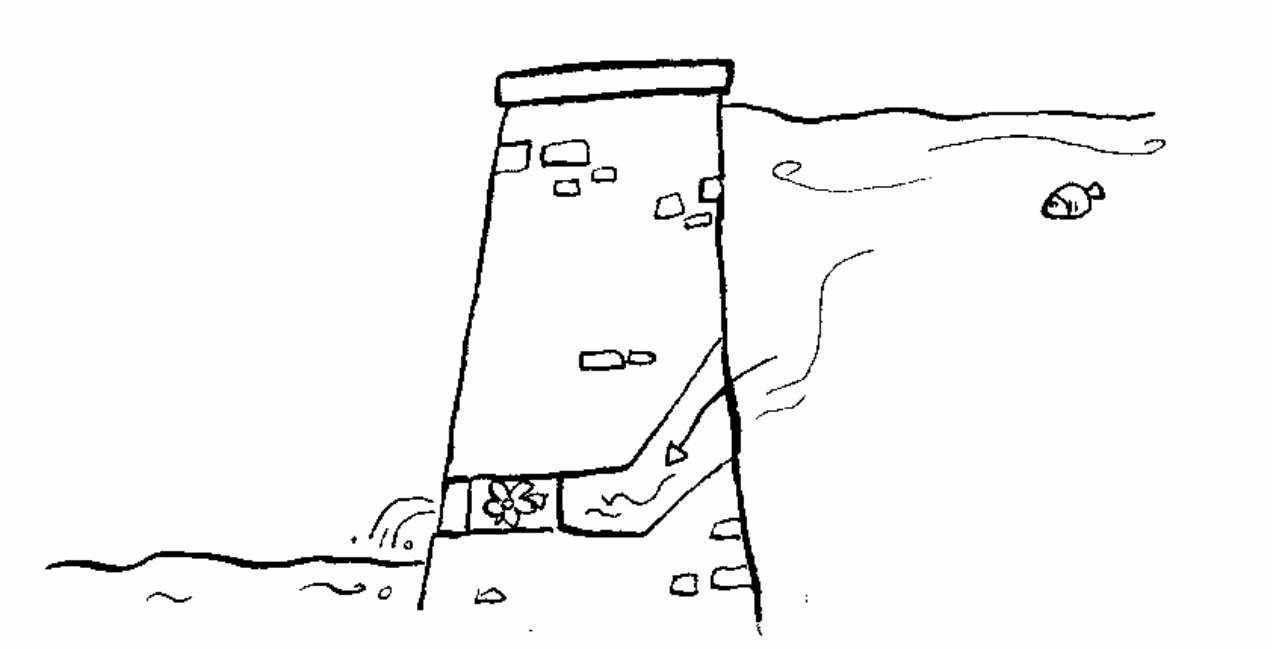
5. Energy in <u>electrical</u> form: this energy is provided through sockets which are found throughout our contemporary homes. This energy comes from power stations, where hydraulic, chemical and nuclear energy is transformed into electrical energy. This energy is then used by most household appliances: television, telephone, lamp, as well as certain types of radiators, in order to easily provide light and heat, etc. As we have seen, electrical batteries also provide electricity of chemical origin. This can be very useful for certain portable applications.



6. Energy in <u>nuclear</u> form: matter in the universe is composed of minuscule particles which are called atoms. These are formed of even smaller particles which are held together by means of nuclear energy. When certain of these atoms are broken, a huge quantity of energy is released. This is the nuclear energy which we use in nuclear power stations* and transform into electricity, but sadly, which is also found in the most dangerous bombs that exist…



7. Energy in hydraulic form: this is the energy in the movement of fluids, such as rivers, the movements of the sea (waves, tides and deep currents), but also the wind. This form of energy is used in mills (wind or water) to grind grain or for irrigation, and this is still the case in many countries. Here, with our barrages (hydroelectric plants*), our waterwheels and wind turbines, we use this form of energy above all by transforming it into electricity.

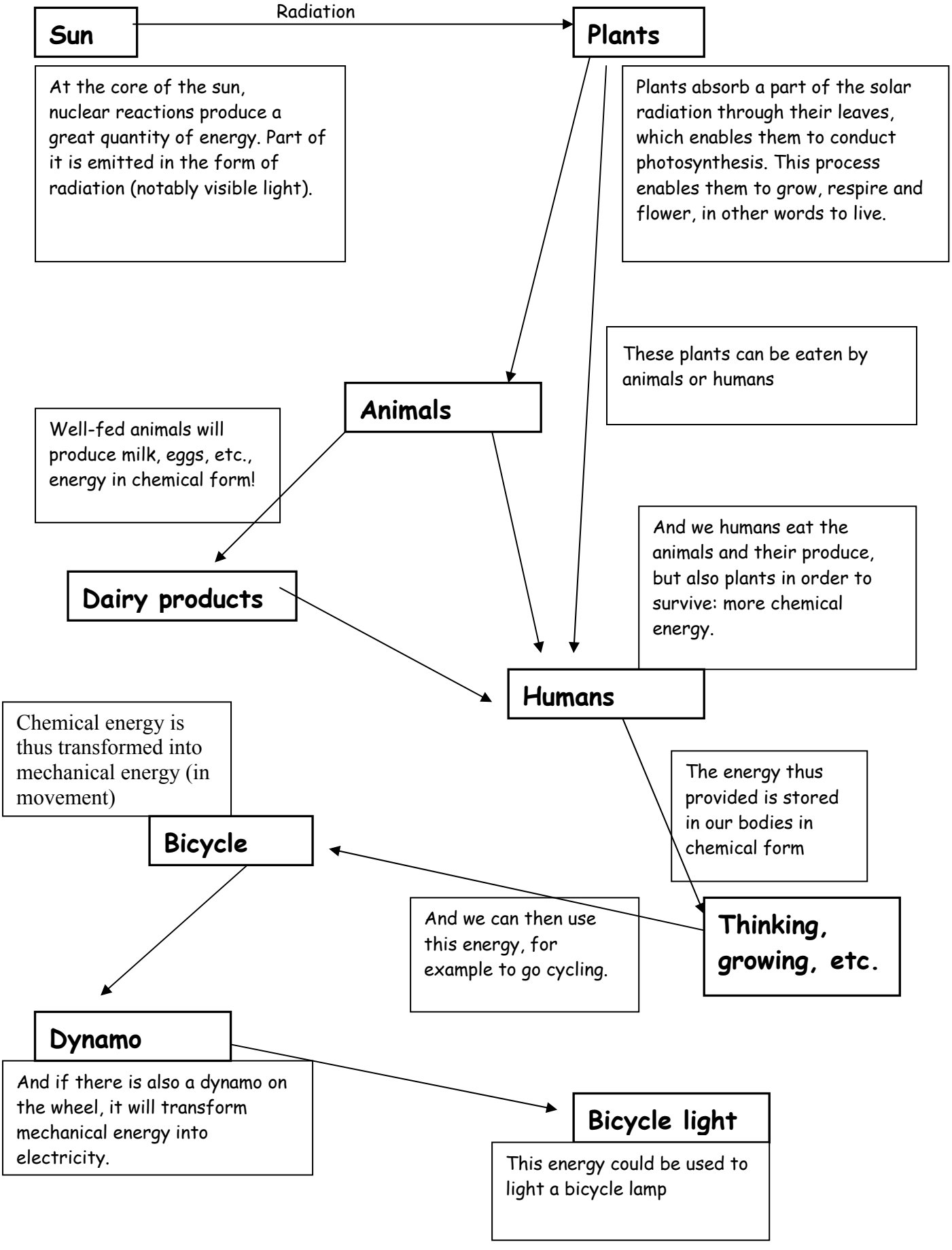


Energy transformation:

As you may have noticed, the forms of energy can be transformed from one to another, but not just anyhow.

Here are a few examples:
Plants transform radiation energy (sunlight) into chemical energy by means of photosynthesis.
Nuclear power stations transform nuclear energy into electrical energy (see the appendix on how an electricity generating station works).
When we go cycling, we transform chemical energy (present in food and digested) into mechanical energy.
When we attach a dynamo to our bicycle wheel, mechanical energy from the wheel is itself partly transformed into electrical energy.

Here is a diagram of a long series of transformations:


Sun
Radiation
Plants
At the core of the sun, nuclear reactions produce a great quantity of energy. Part of it is emitted in the form of radiation (notably visible light).
Plants absorb a part of the solar radiation through their leaves, which enables them to conduct photosynthesis. This process enables them to grow, respire and flower, in other words to live.
These plants can be eaten by animals or humans
Animals
Well-fed animals will produce milk, eggs, etc., energy in chemical form!
Dairy products
And we humans eat the animals and their produce, but also plants in order to survive: more chemical energy.
Humans
Chemical energy is thus transformed into mechanical energy (in movement)
The energy thus provided is stored in our bodies in chemical form
Bicycle
And we can then use this energy, for example to go cycling.
Thinking, growing, etc.
Dynamo
And if there is also a dynamo on the wheel, it will transform mechanical energy into electricity.
Bicycle light
This energy could be used to light a bicycle lamp

It is therefore possible to pass from one form of energy to another, which could itself be transformed into another form, and so on. Nevertheless, as we have said above, this can not be achieved just anyhow. First of all, these transformations always require an intermediary (which we have referred to until now by the word "machine"). The sun for example, in order to have a useful effect such as heat, requires an absorber. Oil, in order to be useful, requires a boiler, that goes without saying, but it is important to understand that any transformation of energy involves a transfer from one mass to another. This always requires a process, be it ancient and natural such as photosynthesis, or relatively new and technological, such as photovoltaic solar panels. Then we have to bear in mind that no transformation is complete and each transformation is accompanied by losses (notably in the form of heat).

Here is a short table which makes it easy to visualise a few of these transformations:

Source of energy	Form of energy	Machine used	Useful effect
Sun	Radiation	Photovoltaic solar panel	Electricity
Sun	Radiation	Leaves of plants (Photosynthesis)	Life
Sun	Radiation	Thermal solar panel	Water heating
Petrol	Chemical	Motor	Movement (mechanical energy)
Natural gas	Chemical	Boiler	Heat for the home
Natural gas	Chemical	Cooker	Heat for cooking

2. What sources of energy are most often used today?

Fossil energies

The three sources of energy most used in the world are oil, natural gas and coal. We call these sources of energy *fossil fuels*. They have two main characteristics which distinguish them from renewable energies (which we shall explain later).

First of all, as their name suggests, these sources of energy are very old. That doesn't mean that they have always existed, but that their (natural) production process has taken thousands (or even millions) of years. This is what prevents us from "making" them, it is not possible to make oil, natural gas or coal. In order to have a supply of these fuels, they have to be extracted from the ground.

Then, as these sources of energy require a very long period in order to be formed, we can say that their quantity is limited. Every time we use oil, natural gas or coal, the natural reserves diminish.

We should also not that these fossil fuels are formed principally of carbon. When they are burned, the combustion* releases what we call carbon dioxide or CO_2, the result of the reaction of the carbon with the oxygen present in the air. We shall see that this gas poses numerous problems, notably in the phenomenon of global warming.

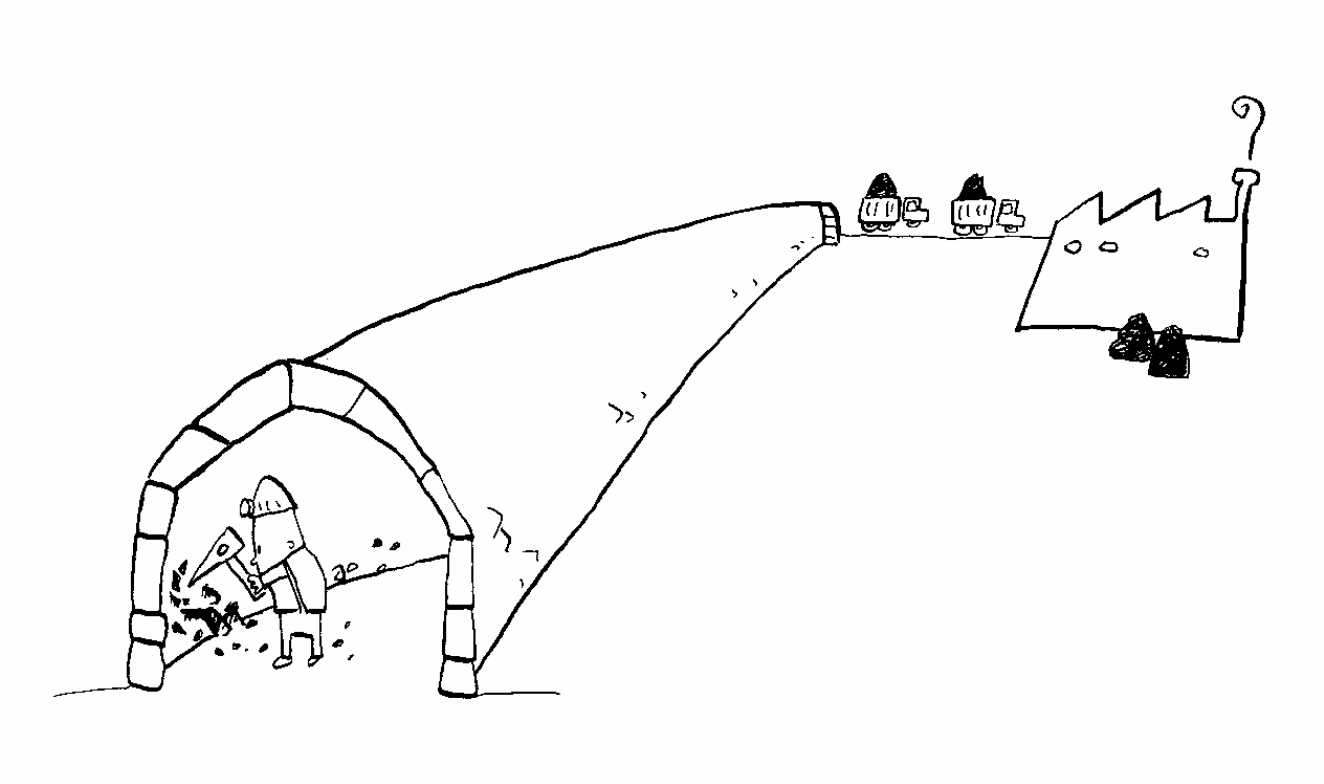
Coal

Coal is formed by the slow, complex transformation of plants (trees and large ferns) which after they have died, were buried in swamps. This plant debris accumulated to be crushed by layers of rock, over the years. Helped by the heat from the ground, these plants were gradually transformed.
The process takes around 300 million years..

There are several different forms of coal: peat, light and spongy, which burns poorly and gives off a lot of smoke; lignite, which is more compact and dark brown in colour, in which you can even see the traces of plants, is used in certain electricity power stations. Coal or anthracite takes the form of a compact, black, shiny rock. These provide the most energy, and are used above all for heating and industry.

Coal is the material which had the greatest importance in the market economic development as we know it today. It was the driving force behind the industrial revolution, which completely changed our society in the 18th and 19th centuries.
It was used as a fuel to work steam engines and to smelt iron ore. But its extraction was responsible for serious accidents, as the miners had to dig for coal at more than 1,200 metres underground.

Nowadays, we use increasingly less coal in Belgian industry. It is nevertheless still used in certain electricity generating stations, as well as in the blast furnaces where iron and steel are melted down.



Gas and oil

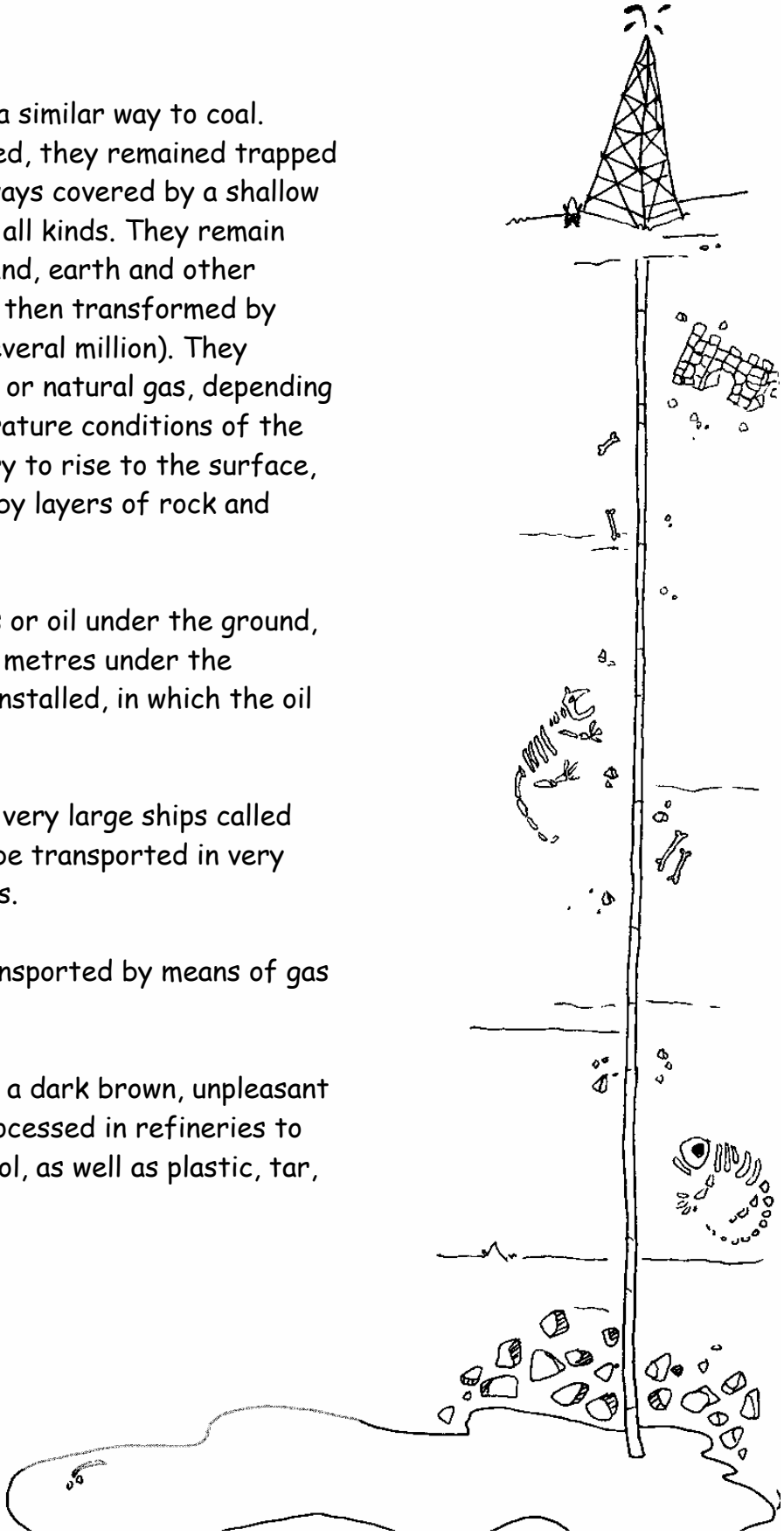
Natural gas and oil form in a similar way to coal. When plants and animals died, they remained trapped under the sea. They are always covered by a shallow layer of marine deposits of all kinds. They remain captured under layers of sand, earth and other matter, are heated and are then transformed by bacteria for many years (several million). They gradually transform into oil or natural gas, depending on the pressure and temperature conditions of the geological layers. If they try to rise to the surface, they are generally blocked by layers of rock and agglutinate in an oilfield.

In order to find natural gas or oil under the ground, we can now drill over 3,000 metres under the surface. A pipeline is then installed, in which the oil or natural gas rise up.

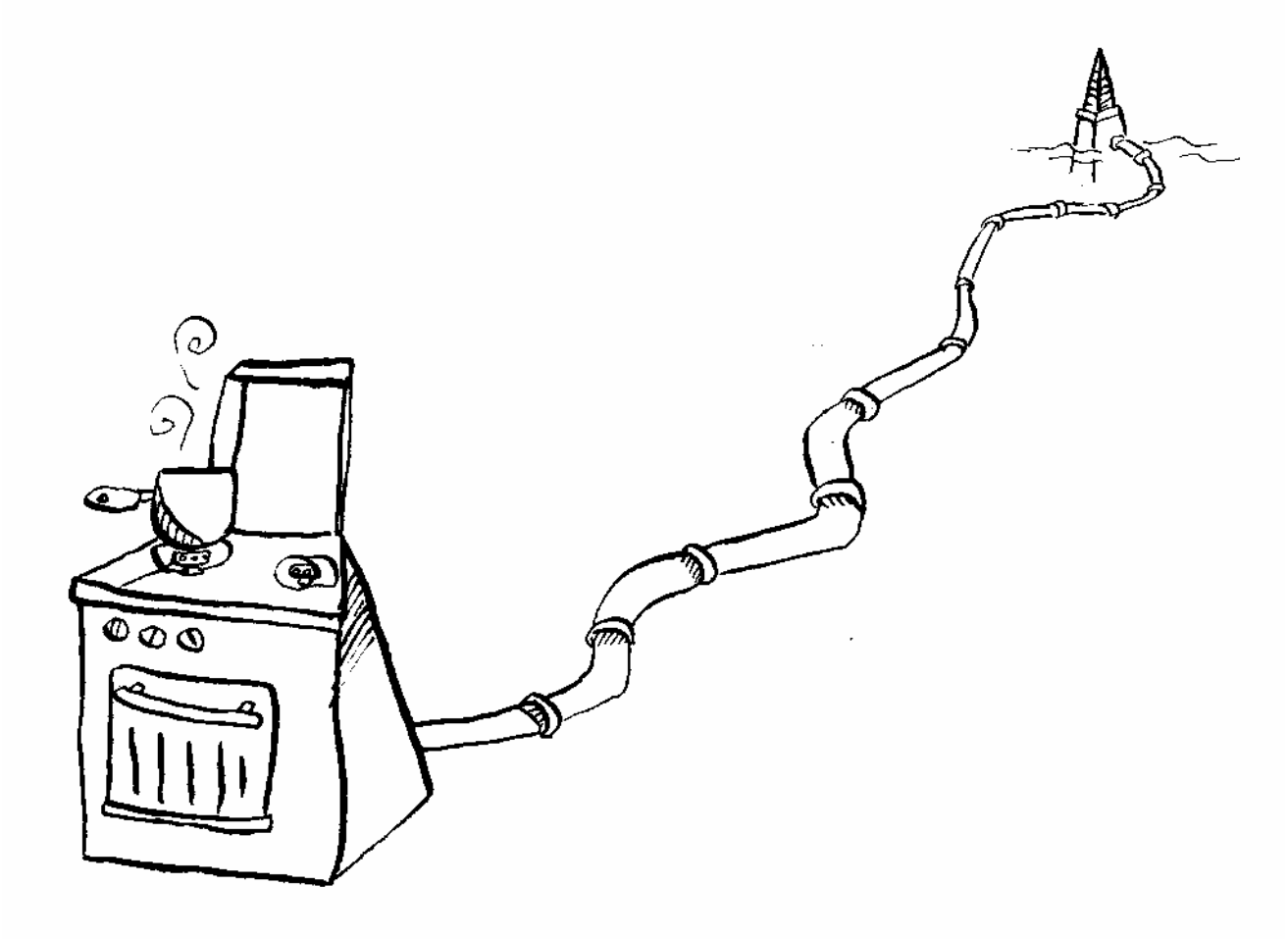
Oil is often transported by very large ships called petrol tankers. It can also be transported in very long pipes called oil pipelines.

Natural gas is generally transported by means of gas pipelines.

Crude oil takes the form of a dark brown, unpleasant smelling oil. It has to be processed in refineries to extract the diesel and petrol, as well as plastic, tar, etc.



The ease with which oil and natural gas can be used has enabled our standard of living to improve further. Transport and heating have been greatly facilitated by the massive commercialisation of oil. Oil is not only used to produce diesel, petrol and heating oil. There are many by-products of oil, such as tar or plastic, which lie at the source of many inventions which we use every day.

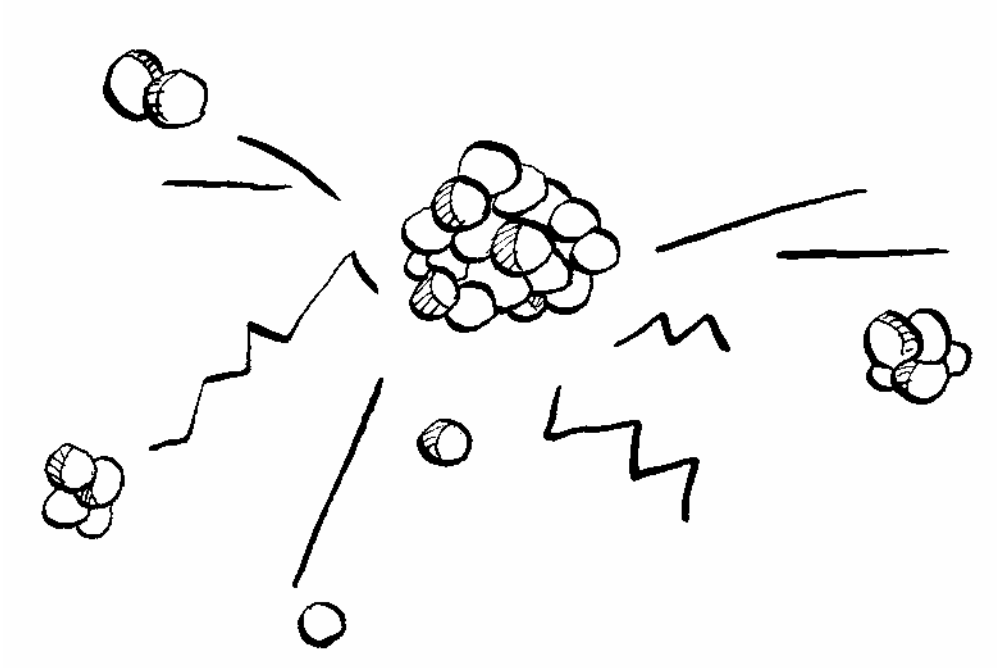


Nuclear energy

As we have already mentioned, nuclear energy is found in the very structures of the matter which makes up the universe. Matter is composed of what we call atoms, very small particles, so small that we can not even see them with a normal microscope. There are 92 stable elements which make up the matter in the entire universe (such as oxygen, hydrogen, nitrogen, carbon, copper, iron, zinc and uranium). These atoms are themselves made up of even smaller particles still: neutrons and protons which form the core of the atom, and electrons which spin around the core. The number of protons determines the type of atom: if there is one single proton, we have a hydrogen atom. If there are two, it is helium. If there are eight, we will have oxygen. The largest atom which exists in its natural state is uranium, with 92 protons (and between 143 and 146 neutrons).

In order to be able to use nuclear energy without too much risk of the reaction getting out of control, and therefore creating a nuclear explosion, we have to control all the parameters of what is called *nuclear fission* (or more generally, just *fission*).

To achieve this process, we have to manage to split the atoms into several pieces. The larger and more unstable the atoms, the easier it is to split them; we use Uranium, which is the largest atom of the 92 elements found in the matter of the universe. We then send a neutron at very high speed into a nucleus of uranium, which breaks into several smaller nuclei, generating an enormous amount of energy.



What remains after this fission are other atoms which are less heavy, but very dangerous for humans. This waste is *radioactive*, which means that they emit fatal radiation. To protect ourselves from these rays, we have to isolate the waste in sealed concrete blocks, and monitor them permanently to avoid any problems. This waste has a lifetime of over 10,000 years, which means that they will remain dangerous for mankind for thousands of years. They will therefore have to be closely supervised for several generations (unless a better solution is found).

This highly complicated process for using nuclear energy is used in our nuclear power stations (there are seven nuclear reactors in Belgium) to produce electricity. Over half, nearly 60%, of the electricity produced in Belgium comes from these types of power plants.

A short history of energy use

Men have not always used energy as they do today, far from it. The history of energy use has accelerated very suddenly over the past three centuries. It has greatly contributed to the profound change in the way humans live, be it from a social, economic or political viewpoint. This didn't happen in isolation, new technical inventions were required which met with or created new social, economic and political concerns, which it is now difficult to call into question.

Before the end of the 18th century, we mainly used renewable sources of energies in the immediate surroundings. We mainly used wood for heat and to cook, as well as for traditional manual trades such as pottery or metalwork. We also used oil or candles for lighting.

Energy in its mechanical form was mainly provided by men and draft animals. Horses and oxen were used by men for transport, as well as for working the land. They even helped to take ships up-river.

Wind and water energy was also used for transport, with sailing ships which travelled on the rivers and the sea. But water and wind were also used to operate mills, to grind grain or pump water from the depths of the earth.

Lastly, solar energy was also used, as our ancestors built in accordance with the sun. We can observe this by comparing the different styles of homes in different countries: houses in North Africa are built with thick walls and few openings in order to avoid suffering too much from the heat of the sun. In our part of the world, we try to make

the most of the sun in summer, but also protect ourselves from the cold in winter, and numerous traditional techniques enable this.

We have known about some of the applications of steam for a long time now, but the invention of the steam engine at the end of the 18th century and its widespread use in all the areas of public life have profoundly changed western society. In fact, the steam engine has made it possible to transform heat into movement! To do this, wood is burned in order to heat water, which then turns into vapour. This vapour is then used, owing to its pressure, to drive a piston. Through a system of arms and pulleys, we then have a very powerful source of movement.

The use of this fine machine spread throughout the western world: factories no longer needed to be located by a river and transport changed radically, as steam trains and steam ships were invented, which made it possible to transport ever greater numbers of people at ever greater speed.

During the 19th century, wood was gradually replaced by coal, which burns at a higher temperature as it contains more carbon, and therefore provides more energy for a comparable quantity. Changes in society continued even faster and with the new development of industry and coal mines, a new type of economy was created at the same time, as well as a new type of poverty. Generations of men and women were sacrificed in the coal mines, living and working in horrible conditions. Great social battles took place, in an attempt to defend workers' rights, and living conditions improved. This unsettled time is often referred to as the "industrial revolution".

At the end of the 19th century and during the 20th century, the use of natural gas and oil developed and with them, the use of electricity.

Electricity made it possible to further change our ways of life: it can be found literally everywhere! Its flexibility and ease of use have made it very popular. We only have to think of everything which works by electricity around us: telephones, motors, public and private lighting, radio, television, etc.
But if electricity appears to be "clean", this is because we generally do not see its source.
The first electricity generators used in factories ran on coal, and each factory had its own generator. Nowadays, we have created what is known as a "network": electricity is produced in power stations and transported just about everywhere along cables, which are either suspended in the air (between pylons) or buried under the ground.

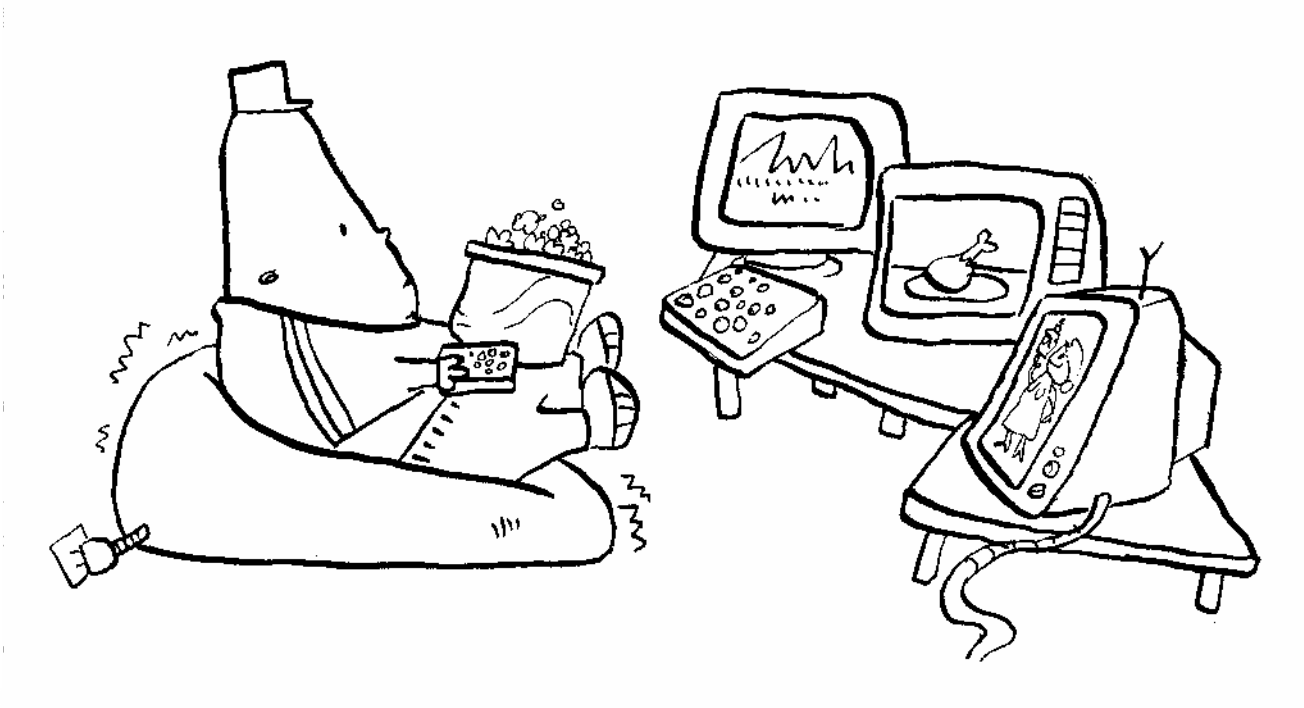
Natural gas and oil are also easy to use, and with them it has been possible to increase the number of factories even further, change modes of transport with the invention of the individual car, change the way in which we heat our homes with the invention of central heating, and many other changes besides, the repercussions of which we see every day around us. After World War II, the consumption of these sources of energy increased even further, until today. But at the same time, we have sent the initial problems associated with this consumption taking an increasingly significant place in political life: initial conflicts over the supply of resources, economic and environmental problems, etc.

During the last half of the 20th century, nuclear power plants were built in order to be able to produce a very large quantity of electricity. This is going to further facilitate access to electricity, but will also pose further problems of risks and pollutions, as we shall see. Advertising, marketing and industry, in order to continue to develop, are going to create an increasing number of new needs, some of which are legitimate, but others are more questionable. In one century, we calculate that we have consumed half of the fossil energy resources…

The advantages of using fossil energy sources

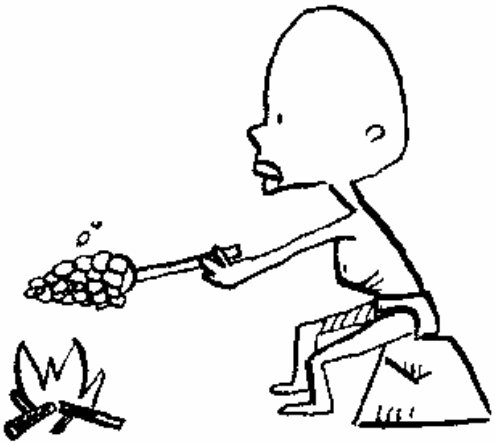
If we use all of these energies today, it is therefore not without reason or history. Indeed, this use has considerably changed our ways of life, but has also made it possible to increase life expectancy in our western societies.

We simply have to think of the way in which we use energy in everyday life. Long journeys as fast as possible, we can all stay in warm places, we have light even at night time, we can wash in warm water, we communicate with people who are very far away as if they were standing next to us, we listen to music when we want to, doctors use increasing numbers of methods to help us live longer, we have food in abundance from distant places, we are informed by the television, radio or Internet, we have lots of warm, cheap clothes, etc.



If it is true that life may seem to us to be expensive, it is also because we always want more… Let's not forget that life for humans has not always been as easy as it is now. But not everyone enjoys this quality of life either. In many countries throughout the world, life is very different from our own.

Did you know that 1/5 of the world's population consumes 4/5 of the energy used by all the inhabitants of the globe?



We have to bear in mind that this is largely associated with the great quantity of energy which we consume every day. Without electricity, oil and gas, our lives would be very different.

3. What problems are associated with energy consumption?

If you increasingly frequently hear people speaking about "green renewable energies" or "alternative, clean energies", it is because the use of fossil sources of energy and nuclear energy also pose numerous problems on a global scale. Before talking about these renewable energies in more detail, let us look first of all at the problems posed by the massive consumption of energy associated with human activities.

Problems associated with the use of sources of fossil energy

If we have come to your school to speak about renewable energies, it is not only for pleasure, but also because nowadays, many people think that our way of consuming energy has to change, and that it is important to speak to both parents and children. Indeed, even if fossil energies at first sight only offer economic advantages and if they have permitted the development of the society as we know it, they also have many considerable drawbacks, which are increasingly affecting our environment. Apart from polluting the atmosphere and contributing to global warming when they are used, fossil energy sources are a source of inequalities in the world, as well as significant tensions, which can lead to very violent, lethal, armed conflicts.

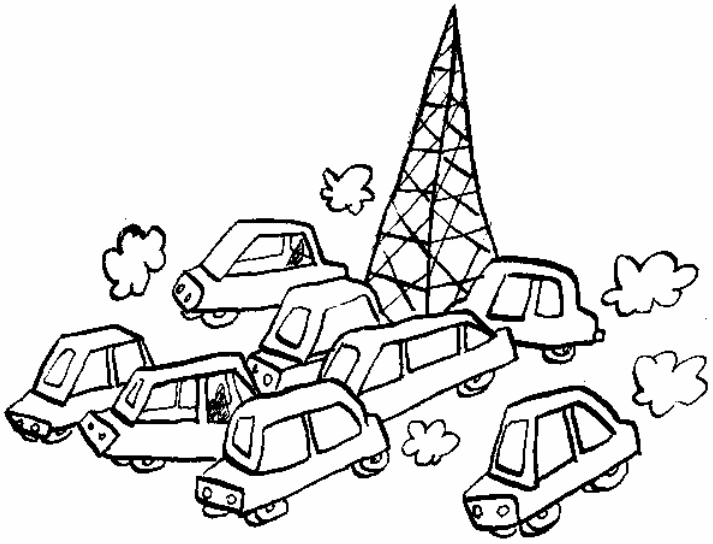
Atmospheric pollution, acid rain and soil pollution

The first problem which comes to mind when we speak of the use of oil, coal and gas is atmospheric pollution. It is true that the gases emitted during the combustion of these materials contribute to the pollution of our environment. They create what is known as acid rain, pollute the soil and are also responsible for the increase in the number of pulmonary diseases. This pollution increases with the quantity of gases emitted into the atmosphere by transport activities, industrial activities and also our domestic activities.

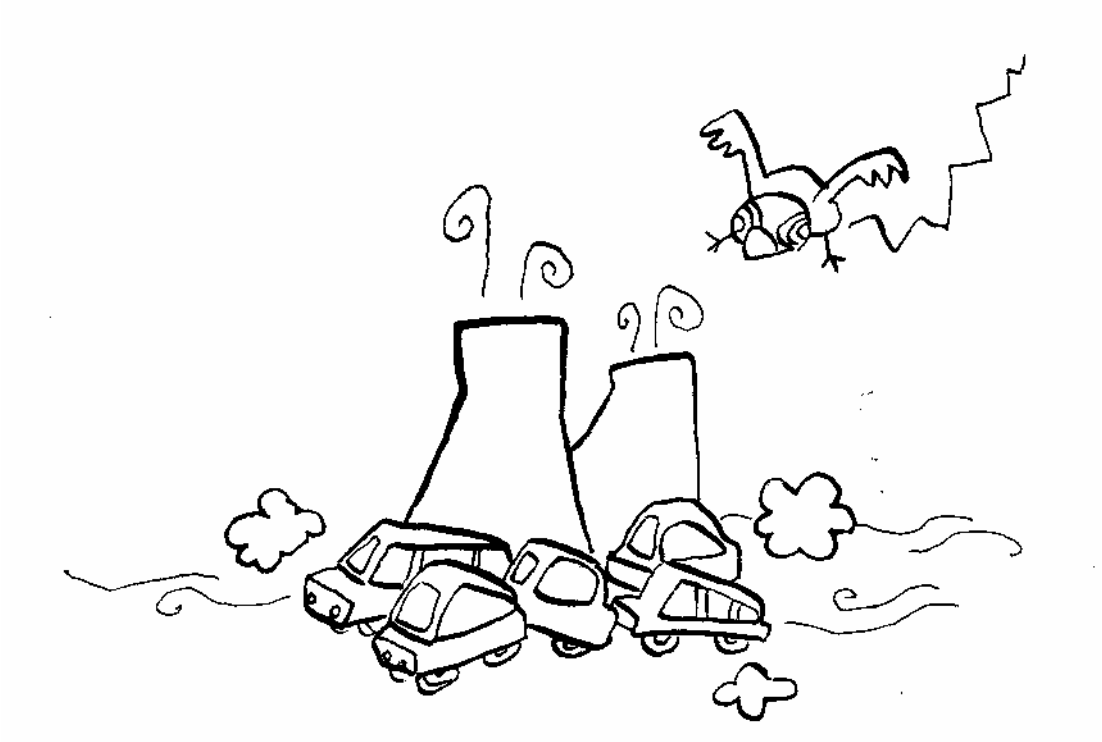
When we breathe some of these gases, they can cause health problems in our lungs, as these gases clog up the part of our lungs which absorb the oxygen which we need. This is the case for example with ozone, which is necessary in the highest part of the atmosphere, but which is dangerous to breathe. During the summer, certain cities such as Paris and Rome recommend that older people and children should no go out of their homes or exert themselves as there is too much ozone in the air. Other gases and

certain types of dust from the activity in our homes contribute to the deterioration of the air which we breathe.

Also, certain elements in the gases emitted by this combustion of fossil energy sources combine with water vapour in the clouds to form acid rain, which falls on the ground with the rain. An acid is a liquid which attacks almost all materials and can be very destructive. These acids are diluted in rainwater, and are not very dangerous in small doses, but in the long term, they can cause great damage to plants and old monuments.



Indeed, this acid rain attacks monuments over time, gradually eroding them, but also homes. They similarly attack forests.
Acid rain also enters the ground, which can greatly influence the survival of all plants as well as animals. Waterways are also polluted, which is also bad for plants and fish, as well as drinking water reservoirs, and therefore humans themselves.



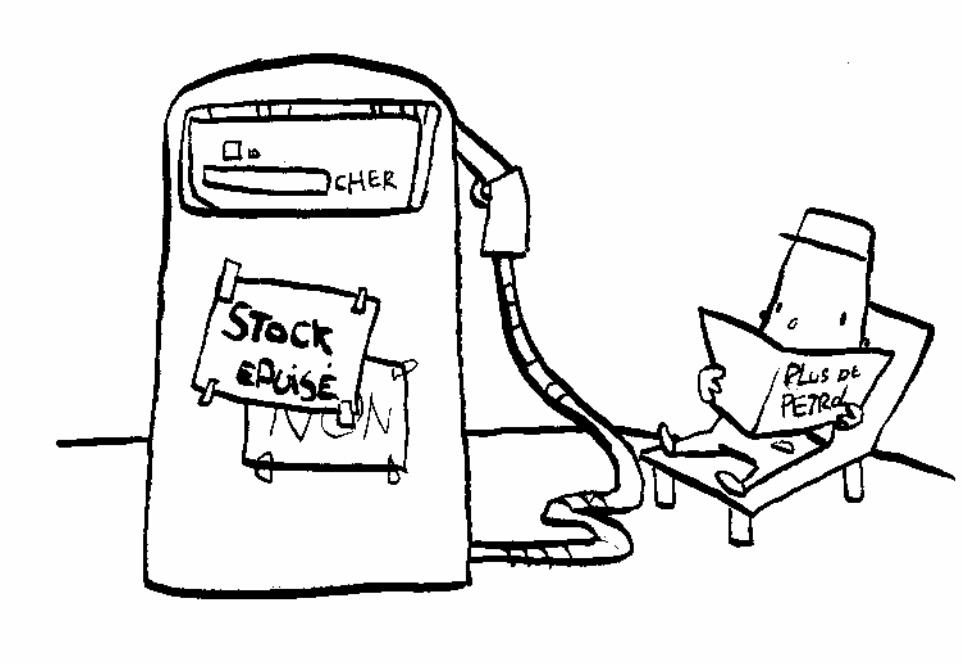
The using up of resources

Another problem with fossil energies is that the quantity of available resources is limited. Indeed, contrary to renewable energies each time I use a quantity of fossil fuels, this quantity is destroyed. I therefore prevent others from using it elsewhere or at a later date, and I contribute to reducing the quantity of available resources.

It is almost impossible to know what quantity of oil, coal or natural gas is still available. But most people working in this sector believe that at the current rate of use, currently exploited oil reserves will have disappeared in 40 years, natural gas in 60 years and coal in 150 years. These figures are difficult to confirm and are at the heart of serious controversies, but it is undeniable that the quantity is reducing every day.

This reduction in resources is gradually causing the price of energy to rise, which runs the risk of initially depriving the poorest people from using them, thereby accentuating social inequalities.

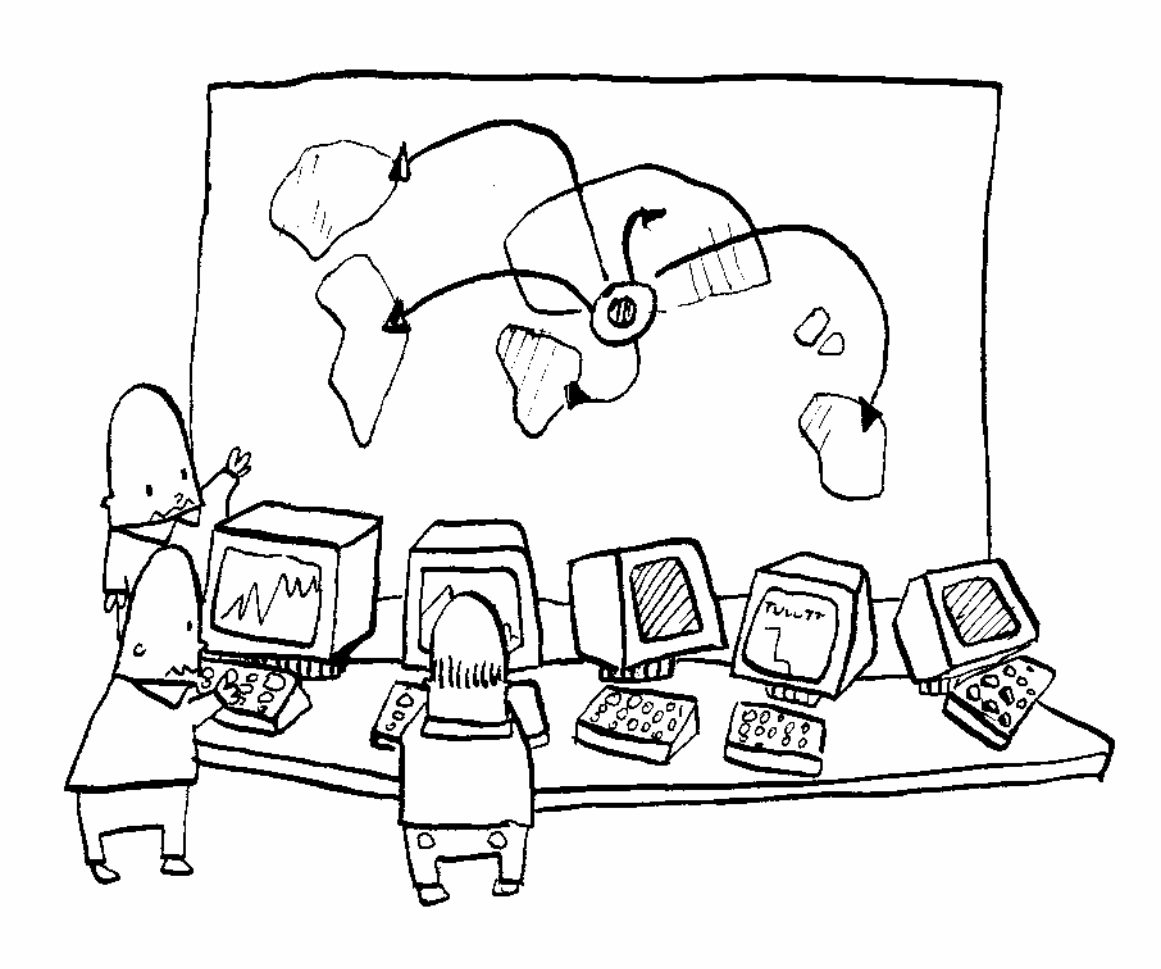
Finally, when a widely used product becomes rare, men fight to obtain it. The rarefaction of fossil energy sources is already causing many conflicts, as we are going to try and understand right away.



The distribution of des energy sources throughout the world: a source of danger and conflicts

The sources of fossil energies are not present everywhere in the ground throughout the world. The Belgian subsoil is for example rich in coal, which was exploited during the industrial revolution to supply the numerous factories and to enable Belgium to develop economically. We now use a lot more coal than in the past, and the source which is mainly used nowadays is oil.

Oil is mostly found (two-thirds of worldwide reserves) in the countries around the Persian Gulf: Saudi Arabia, Iraq, Kuwait and Iran,



When a country does not have a source of energy in its territory, it has to import it, that is to say, buy it from companies in another country. This poses major problems in two respects: transport and the international tensions which it can create.

First of all, the source of energy has to be transported, and this can be dangerous. To transport oil, we generally use tankers, which can be shipwrecked, causing an oil slick which carries crude oil onto the beaches of several countries. These oil slicks cause serious pollution, damaging the wildlife of the affected regions: the lives of birds, plants and fish are threatened. Fisherman are made redundant, not to mention the deterioration of the landscape (which also discourages tourists). In order to transport gas, we can use gas pipelines, which are very long pipes that often cross numerous countries, over vast territories. This is expensive and they have to be supervised in order to avoid pillaging or ecological catastrophes.

This unequal distribution of sources of fossil energies causes conflicts on a worldwide scale. As oil is a highly coveted resource, which is difficult to access and unequally distributed, it is therefore very expensive. Anyone who can sell it can quickly become very rich, and control an important product for the whole world. Numerous people may therefore want to fight to gain control over oil wells. We have to realise that today, everyone wants to be able to use oil and natural gas easily, as these sources of energy have become necessary for the proper running of our society.
Oil and natural gas are used everywhere in industry, for transports, etc., which is why everyone needs it. And when something which is necessary becomes rare, its price increases, which annoys everyone and can lead to people getting into disputes.

Why? The example of natural gas and oil is perhaps not very obvious, so let's take another: bread, which we all need to eat. If the baker only has one loaf of bread left in his shop and ten people want o buy it, what will happen? We could try cutting the loaf into ten pieces, which would be the most equitable solution as everyone would have the same amount. If everyone agrees, the result could be satisfactory. But it only takes one or other person who does not agree (for example because they have to feed their whole family and a small piece of bread will not be enough) for things to become more complicated.
The way to deal with this situation in our societies is to raise the price of bread: the person who is prepared to pay the highest price will finally get the bread, and the others will have to manage without.
The problem becomes complicated when it is difficult to manage without, for example if there is no other bakery nearby…
Customers may lose their tempers and start fighting, arguing, insulting on another, in short, it's chaos as everyone wants bread and things may end in disaster!

Well it's the same thing for oil. Everyone needs oil, and if there is increasingly less, the price is going to rise. If prices rise, there is a risk that certain people will no longer be able to pay for it (of course, the poorest people will be hit first) and they will not agree on what to do, which could lead to conflict… The richest people could also want to

protect what they are capable of buying, by becoming the masters of fossil energy sources by force or by money. This is a very delicate and complicated situation, which is not at all easy to resolve.

Finally, we would note once again that everyone in the world does not consume the same quantity of energy, which is a deep-rooted source of social inequalities. Most people do not have access to electricity, natural gas or oil. It is already difficult to find drinking water in certain regions. These inequalities are very deep-seated; most countries in the world are in a precarious situation. The increase in energy prices is therefore a source of additional concerns for these countries.

Fortunately, there are paths towards solutions, which we shall discover a little later, after having attempted to understand the risks of using fossil energies on the environment.

What is the greenhouse gas effect?

We often hear people talking about the greenhouse effect, and its main consequence: global warming. We should understand that the greenhouse effect has always existed on Earth, but there is a risk that it will be increased with the emission of certain polluting gases.
But let's first look at what is known as the "greenhouse effect" in order to better understand what might happen to our world if we are not careful.

The greenhouse effect means that *heat is retained* in an enclosed area. In a greenhouse, we try to keep in the necessary heat in order to grow vegetables, even if it is cold outside. The greenhouse effect also takes place in our cars which are left in the sun: they get very hot inside.

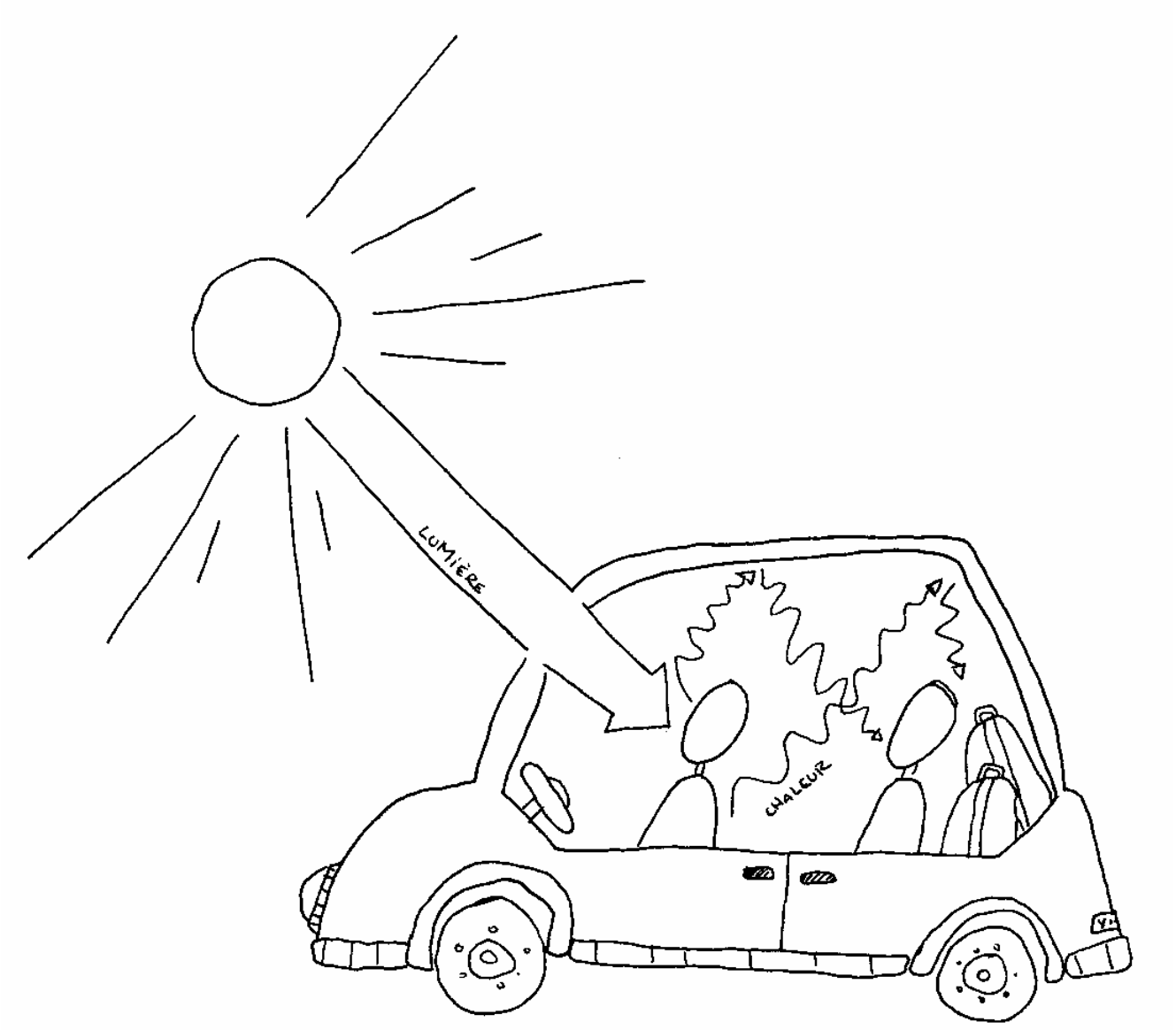
How does this happen? We first need a transparent material which allows the light to pass through it. In greenhouses and cars, these are windows.

The light can therefore pass through these "windows", this transparent material, and hit the surface below it. This light is then going to be absorbed in the form of heat. In greenhouses, the sun hits the ground and warms it up. In a car, the sun hits the dashboard, the seats, the steering wheel and all the other parts inside the car, and makes them heat up.

This heat is then going to want to "escape"; it is emitted by the material which has been heated. In the same way, every hot object emits heat towards the exterior. If a radiator heats a room, it is because it emits its heat in the space around it. We say that there is a heat emission.

But in the case of the greenhouse effect, this heat is going to be retained within the greenhouse by the transparent material, this heat can not escape therefore. In order for there to be a greenhouse effect, the glazing has to allow the light to pass through it, whilst retaining the heat.

In a greenhouse, the sunlight passes through the glass and heats up the ground. This heat is emitted in the greenhouse, but is retained by the greenhouse's windows, which enables the interior of the greenhouse to remain nice and warm. The glass windows maintain the heat very well, which is also why it is warm in a house and all the heat does not escape through the window.



[light - heat]

The same thing happens in a car. The rays of sunlight pass through the windows and heat up the interior of the car. This heat is then trapped within the car, as it is incapable of passing through the window. This is why it is so hot in a car which has been parked in the sun. Even if, to be accurate, we have to admit that part of the heat escapes from the car (it is not heated up infinitely), most of the heat is trapped inside.

To summarise, we can therefore say that with the greenhouse gas effect:
The light can pass through a layer of highly transparent material, although it does not allow the heat to pass through it.
The material which is underneath this transparent layer is hit by light rays and warms up.

The heat emitted is retained within the inside of the greenhouse by a layer of material which prevents the heat from escaping.

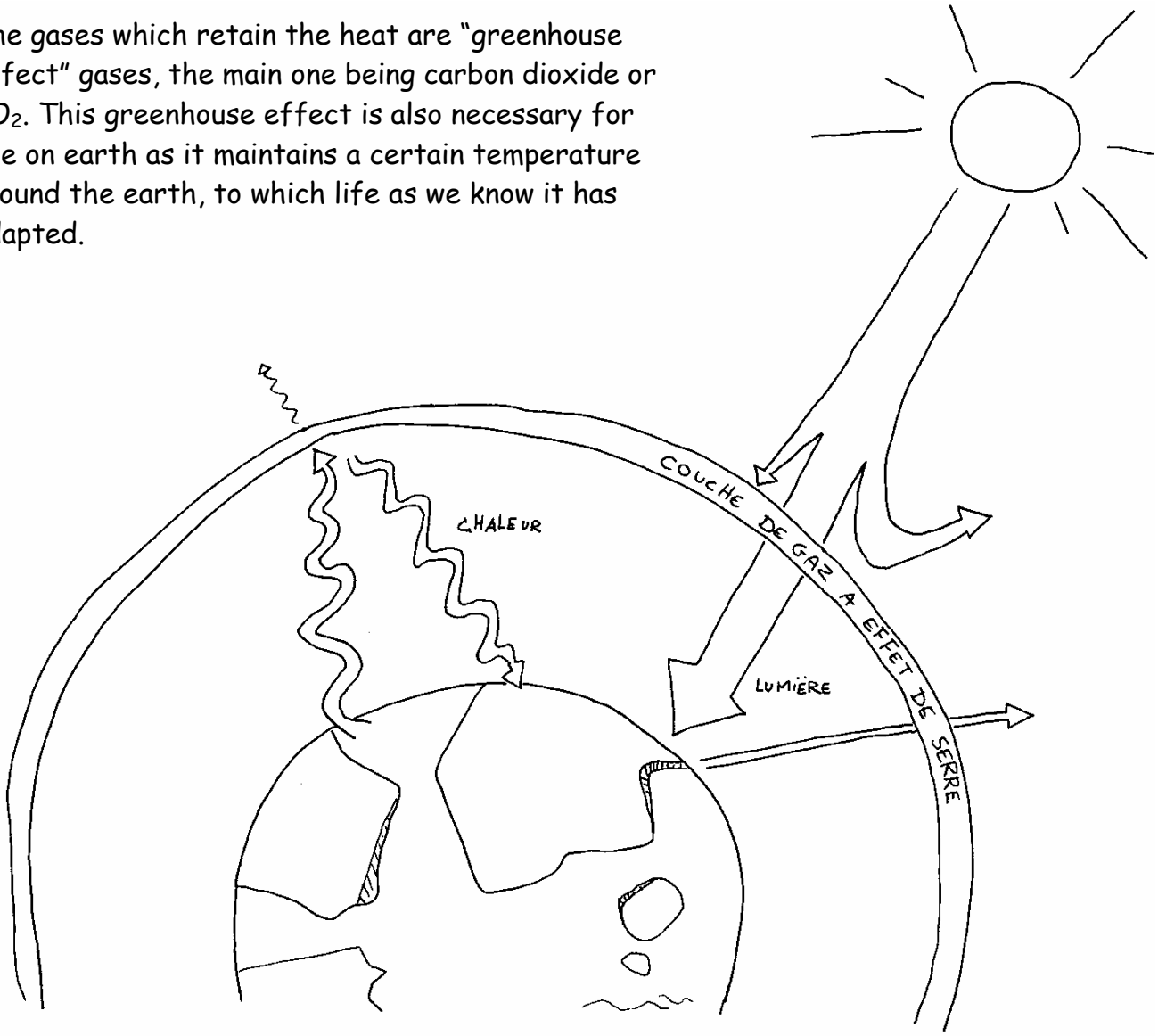
The same thing is happening to our planet.

This greenhouse effect is not a bad thing in itself. Indeed, the purpose of a greenhouse is to retain the heat, it is the greenhouse effect which is sought. In a greenhouse, we want to keep in as much heat as possible so that we can grow beautiful vegetables and plants, even if it is cold outside. For the Earth also, this greenhouse effect is vital for us, for without it the world would be much colder and life would not be possible. On the other hand, we have to take care not to intensify this effect, otherwise we risk experiencing a climate change… this is what we are going to try and understand on the next section.

Intensification of the greenhouse effect on the Earth

On the Earth, there has always been a natural greenhouse effect, which enabled life to appear as we know it. Without it, the night time would be very cold and the days would be torrid. How is the greenhouse effect produced on the Earth? In the same way as in a greenhouse or in a car.
Light rays from the sun first of all hit the layers of gas in our atmosphere. These filter these rays and prevent the dangerous rays for humans and nature from passing through, but it lets the light pass.
This light then hits the ground on the earth, where it is partly absorbed in the form of heat: light therefore heats up the earth. This heating effect is normal and makes life on earth possible.
This heat is then emitted by the earth, just as any hot object emits heat (like a radiator for example). As in any greenhouse effect, the heat is then partly retained around the earth through the atmosphere.

The gases which retain the heat are "greenhouse effect" gases, the main one being carbon dioxide or CO_2. This greenhouse effect is also necessary for life on earth as it maintains a certain temperature around the earth, to which life as we know it has adapted.



heat – layer of greenhouse effect gas - light

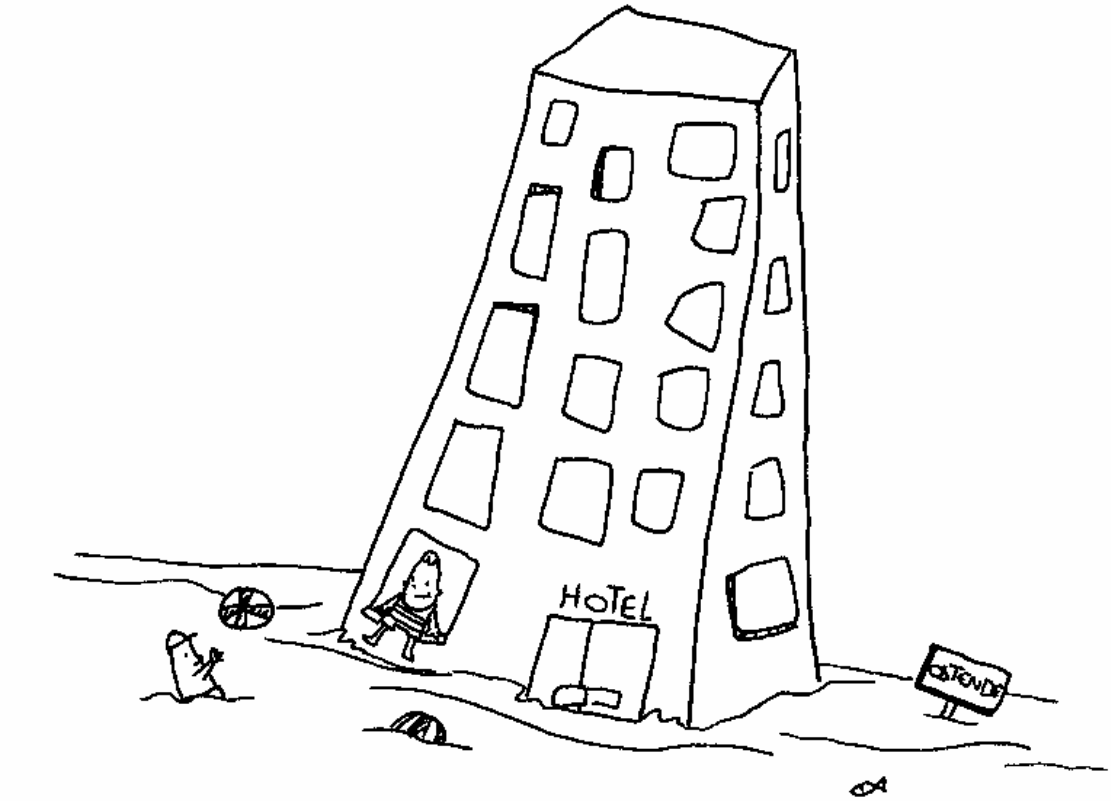
But when we use fossil energies and we burn them, we emit CO_2, a gas which intensifies the atmosphere's capacity to have a greenhouse effect. Other gases are also responsible for this intensification of the greenhouse effect, such as the gases which are produced by the organic decomposition of animals and plants, aerosol products, the evaporation of certain chemical fertilizers or even the industrial waste from certain factories. The gases contained in the tubes of old refrigerators are also responsible for intensifying this effect, which is why it is important to take care when we dispose of them, and it is obligatory to recycle them.

What the intensification of the greenhouse effect means.

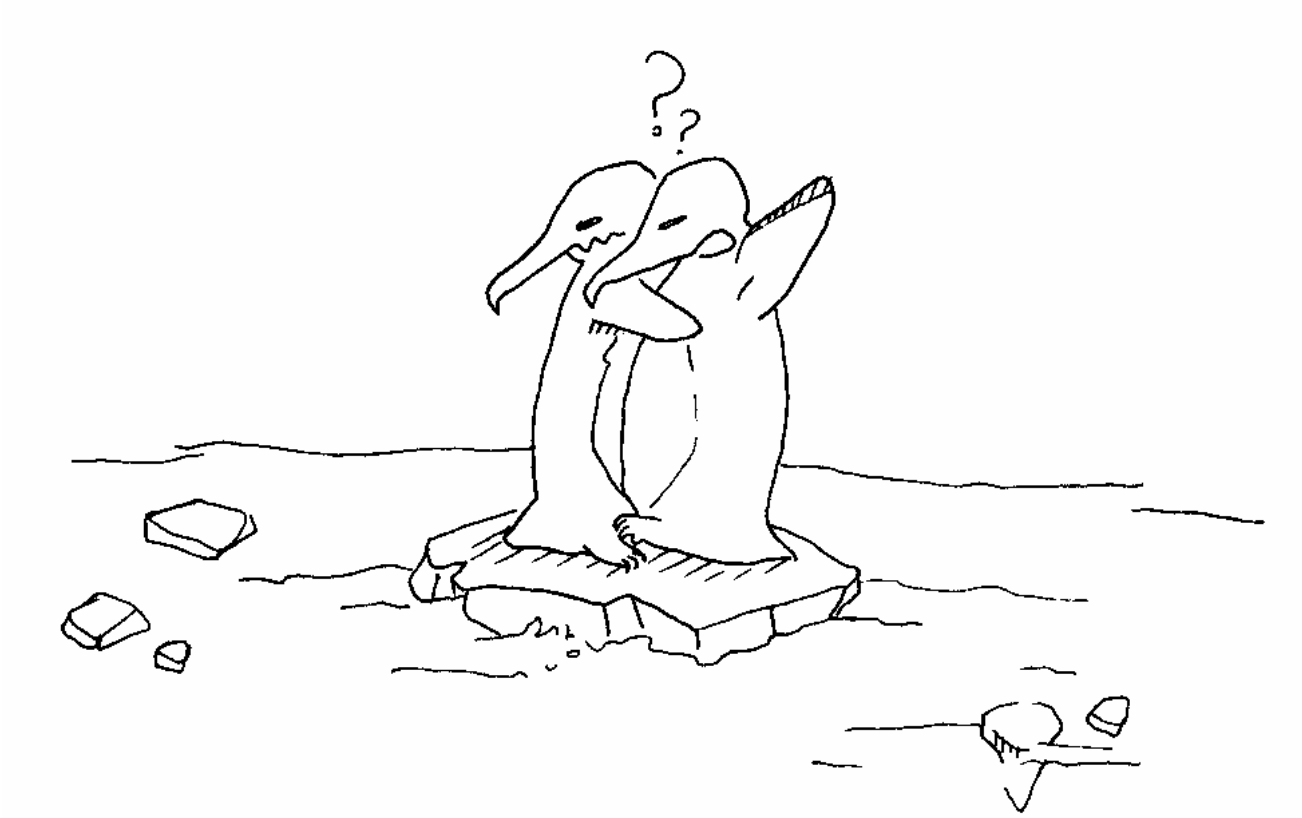
The consideration of problems related to the intensification of the greenhouse effect is a new social phenomenon, which results from an interesting history. For many years now, groups of scientists as well as people who are conscious of environmental issues have begun to think that greenhouse gas emissions could have a negative impact on our planet. But they were not listened to initially, for a number of reasons. We might think that taking into account this type of problems was not part of the generally accepted way of asking political questions. To make the world listen that there was a danger for the earth, these groups had to alert a lot of people, not just scientists. These issues called a lot of issues into question, the foremost of which included our modern way of life and our enormous financial interests. It was not enough to say that the intensification of the greenhouse effect was dangerous for it to be taken on board politically. It involved, and still does involve today debating the numerous economic, social, political and scientific issues to attempt to grasp the scope of this phenomenon.

The intensification of the greenhouse effect on the Earth actually provokes a climate change for our world. The only thing which we do not know is the scale of this change. The emissions of gases resulting from the industrial revolution have already increased the average temperature of the Earth by 0.8°C since 1860, but specialists forecast an increase of between 1.4°C and 5.8°C between now and 2100.

This temperature increase risks having disastrous effects on human, animal and plant life. The number of phenomena may indeed intensify and influence one another.
The rise in temperature threatens to increase the volume of water on the planet (as when a body heats, it always increases in size), which could make the sea level rise by 1 metre between now and 2100. This may appear small, but it is enough to flood many island states and the coastal regions of many countries. We will therefore be obliges to move millions of people.



The average temperature increase does not mean that the temperature is going to rise by the same amount everywhere at the same time, as many parameters come into play: it may be reflected by a temperature increase in certain regions and by a fall in other places. Winds and the temperature of marine currents will also be subject to significant variations, further intensifying the danger.
For example, global warming could affect the northern hemisphere in particular, even causing the ice cap at the North Pole to melt (Arctic).



But this temperature increase also threatens to provoke serious changes such as an increase in rainfall in certain regions which would then be regularly flooded, whilst other fertile areas of the world risk becoming arid deserts (hot or cold). These changes will also affect the poorest countries which survive by cultivating the land: harvests will become increasingly unpredictable, difficult to manage and probably poorer. Not to mention the destructions which it threatens to provoke among animals: climate variation could destroy numerous species which are incapable of adapting to their new habitat.

Take care not to confuse:

The melting of the ice caps
The rise in the sea level.

At first sight, one might think that these two phenomena are related, and that the ice which melts is likely to increase the sea level… But this is not the case!
The melting of the ice caps is a serious problem, which threatens to cause the environment of certain species to disappear and to contribute to climate changes. But it is not responsible for the rise in the sea level.
In fact, when it melts, the ice becomes water which actually takes up less space… We can do a small experiment to understand this easily.
First of all, in order to see that ice takes up more space than water, you simply have to fill a plastic bottle with water and put it in the freezer overnight… you will be surprised by the result the next morning! The water will have turned into ice and will have expanded. If your bottle was filled to the brim, it might even have broken… This is why you should use a plastic bottle rather than a glass one, which could be dangerous as you might cut yourself.
Secondly, you can also fill a glass of water and ice cubes floating on the surface. Draw a line to see the level of the water and wait patiently until the ice melts… you will see that the water level does not change.

The rise in the sea level is in fact the result of a phenomenon known as "thermal dilatation": all objects expand a little when they are heated, we say that its volume increases with the temperature… Heated water takes up a little more space than cold water. On the scale of a glass of water, this is not easy to see, but with as much water as there is in an ocean, it takes on more significance.

Problems related to the use of nuclear energy

Nuclear energy is the source of over half the electricity produced in Belgium (60%). This enables us to benefit from an abundance of electricity at a low cost. Just like the use of fossil energies, nuclear energy poses a problem. But the impact of nuclear energy is not of the same nature as for fossil energies.
Indeed, nuclear energy creates less greenhouse gas, as a nuclear power station only emits water vapour into the atmosphere (the result of the cooling process of the reactor). This can nevertheless pose a problem; it does have an impact on the environment (heating of waterways and local pollution).
But the main problems of nuclear power stations are the risks of accidents and the fact that nuclear waste is very dangerous material, which has to be stored and monitored for many centuries.

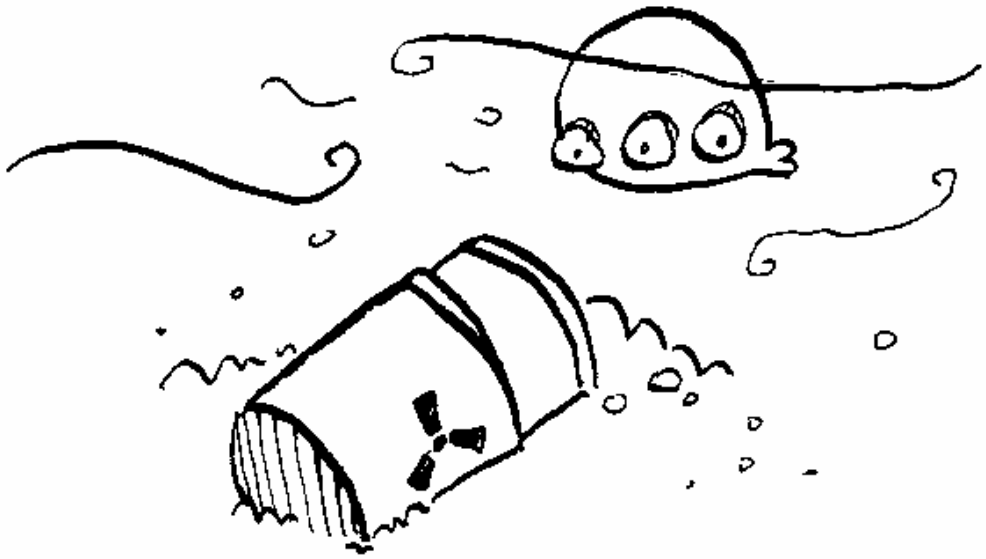
The dangers of nuclear disasters

There is always a danger that nuclear reactions will get out of control and therefore cause an explosion in a power station, even if in modern power stations this risk is extremely small. The consequences of such an accident are very serious, it is probably the most dangerous form of pollution.
Indeed, apart from the immediate deaths, the explosion of a nuclear reactor creates a radioactive cloud which contaminates everything it passes over. The inhabitants of contaminated areas risk very serious illnesses such as cancers and leukaemias, and children who are born are at risk of serious malformations. As the soil is also contaminated, it is no longer possible to grow food there, otherwise the risks are increased even further, for several decades.
There have already been several accidents of this type (even though the first power stations date back to the 1960s) such as Chernobyl in 1986, which resulted in many victims on the actual day, but continues to kill people even today.
We should nevertheless repeat that the risk of such a disaster occurring in the modern power stations is almost zero, as the reactors used nowadays in Belgium are designed to prevent any risk of propagation of the nuclear reaction, even if it continues to make many people frightened.
The evolution of nuclear power stations is a good example of society's influence over scientific knowledge and technical applications. Indeed, following fears legitimately caused by nuclear power stations, pressure groups were set up, which forced scientists to increase security in power stations. By questioning scientists, these groups obliged the scientists to ask themselves further questions and to imagine disaster scenarios which had been ignored up until then. If power stations are now far safer than they were several years ago, it is also thanks to these non-scientific people who dared to ask disturbing questions.
Currently, what poses the most problems is not really the issue of safety in the power stations, but rather the issue of nuclear waste.

Nuclear waste

The most serious problem is that of nuclear waste and their processing, as it is a problem to which no acceptable solution has currently been found. Indeed, nuclear waste remains radioactive (and therefore very dangerous, even lethal) for very many years. A power station produces several tonnes of waste per year, which quickly creates an enormous quantity on a global scale, in all countries.

How do we process nuclear waste nowadays? This waste is first sorted according to its danger, that is to say its level of radioactivity. It is also sorted according to the time during which it will remain dangerous (this is known as the lifetime of the waste). We consider that its lifetime is long if it remains dangerous for more than thirty years, but some remains radioactive for several thousand years.
The most dangerous waste has to be sealed inside huge blocks of concrete, which are known as sarcophaguses.
Several solutions exist to store waste, but not of them are really satisfactory in the long term. Indeed, what can be done with waste that is so dangerous and active and also for such a long time? Can we pass on such huge quantities of lethal matter to future generations?
It is a question of responsibility to future generations, those of our great-great-great grandchildren …



The shutting down of nuclear power stations in Belgium

We should also note that the quantity of Uranium, the material used in nuclear power stations, is also limited.
The consideration of all these problems has forced the Belgian authorities to decide to close down all the existing nuclear power stations between now and 2025. The problem is then to know how we are going to be able to produce electricity in other ways. But it also involves attempting reduce energy consumption to a minimum, in order not to damage our beautiful planet too much.

Conclusions

Humans have gradually learned that their actions have an impact on the environment. This is the result of a fragile equilibrium, that human activity is capable of disrupting, leading to unforeseeable consequences.
We are all part of human society, whether we like it or not, and many of our actions connect us with others. We simply have to look around us to realise this: where do our clothes, the car we derive in, the apples and bananas we eat and the furniture in the house, the television, radio and other objects which we use come from? In fact, they are made just about everywhere in the world! And the fact that we buy them and use them is already a little link which we create. When your parents take political decisions, they are also connected to others. Indeed, politics, economics, science, technology, industry, etc, form part of a whole, whose parts are always connected, even if we sometimes tend to separate them to understand them better. This is also why social problems are so complicated.

The problems which we have just considered are also connected to one another: there are no clothes without industry and no industry without energy consumption. We are all connected in some way with environmental problems, and not only when we throw litter on the ground. It may seem a long way off, and that is true to a certain extent, it is a long way away. But it is also very close to us, as it is present in some way in our actions in our everyday lives and in our way of life.

Obviously, we shouldn't feel guilty about all of these problems, we live in the same way as our neighbours, and we have only realised their importance very recently. But by realising them, we then become capable of gradually changing things, so that our children and grandchildren no longer live in the same kind of world. This is not always easy, but the beginnings of a solution are already to be found in daily life, as we are going to see.

4. How should we respond in the face of problems related to energy use?

All of these problems relating to energy probably seem quite remote, and it may be difficult to understand how we can do anything to influence them.
Nevertheless, each of us can contribute to improving the situation and therefore our way of life, health and the environment.
Several types of solutions exist to these problems: we have decided to focus on the ones that appear to be the most relevant today, as they are practical, they exist now and are not too complicated to organise. We have deliberately chosen not to rely on potential future technical solutions, which do not yet exist in practice for the moment. We are not going to discuss science-fiction today, even if it is possible… Why have we chosen to do this? Because we believe that it is our responsibility to do as much as we can right now, politically and civilly, and not only to wait for better times when "scientists" have managed to sort everything out, because there is nothing to suggest that this is going to happen.

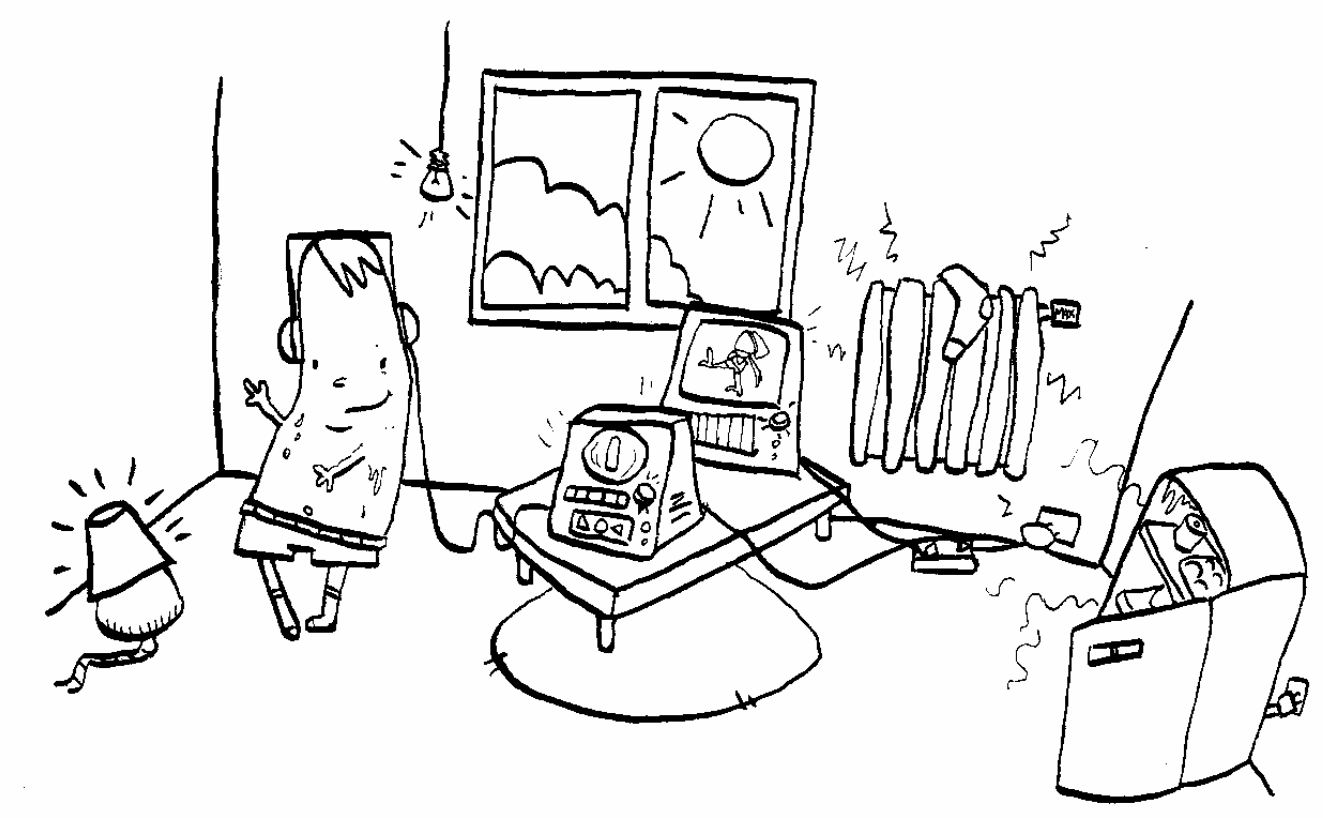
We are therefore going to focus on the possible answers today, practically, technically and politically.
First of all, we have to reduce everyone's unnecessary energy consumption, by not wasting it.
There are two possible methods for this. The first is to change our behaviour in our everyday life, by attempting not to use energy when we don't have to. For example, it is pointless heating a room if the windows are wide open, or leaving lights on if there is no one in the room. We shall look at all of this in more detail.
The second possible method, which has to be combined with the first, is to use increasingly efficient machines. There are an increasing number of machines which do exactly the same thing as older machines, but which consume a lot less energy. There are "low energy" light bulbs for example, which use less electricity to produce the same quantity of light.
Of course, it's not because a light bulb uses less that it has to be left on when no one needs it! The two methods have to be used together. We are going to see how this is possible, and that it can result in a great saving in energy.

There are then alternatives to replace polluting sources of energy with clean and renewable energy sources. The public authorities have decided to promote this type of energy in order to reduce the negative effects of using fossil and nuclear energies, whilst maintaining the advantages associated with using energy. There are numerous ways of producing energy cleanly, without using up resources, which is what we shall look at next.

The authorities throughout the world realise the dangers of our current energy consumption: major international meetings have taken place, during which our world leaders have decided to reduce emissions of polluting gases. The two main international meetings took place in 1992 in Rio in Brazil and in 1997 in Kyoto in Japan. Since then, the countries have met regularly in order to discuss possible solutions. This is not easy, but if everyone makes an effort, it will gradually become possible.
In our country, the government of the Walloon Region has decided to launch a public information campaign on these issues of energy and pollution. Many forms of assistance have been introduced in order to help produce energy in other ways by means of clean energy sources, as well as to explain to people how to make better use of energy.

What can I do as an individual?

In order to reduce the negative effects of energy use, we can all begin by trying to save this energy and avoid wasting it. We call this "rational use of energy".
This involves taking into account the energy which we use every day, without even thinking about it comes from a source which risks having a negative impact on our planet. We therefore have to do all we can to reduce this damage in order to preserve our future and that of our world.



Energy savings.

How can we use energy rationally?
First of all, we should not use energy which we do not need. A huge proportion of the energy consumed is not useful (for example a lamp lit in an empty room). It is important to use the energy instruments which we own only when we need them, and not leave them on unnecessarily.
We can also take care to use efficient equipment, which does not waste energy. Apart from taking care of our planet, this enables us to save money (as we always have to pay for the energy we use).

Here are a few examples of ration energy use in everyday life:

For household equipment: savings begin with the intelligent use of all the electrical or gas appliances in the home. These offer us an excellent quality of life every day, but they all have a cost in terms of energy.
First of all, an appliance which is well maintained always works better and uses less energy: a clogged up appliance always required more energy to produce the same effect.
We can also reduce pointless energy consumption by checking that we have completely switched off the domestic appliances which are no longer being used: switching off lights in rooms which are not being used by anyone, putting out pilot lights (the little lights which stay on on the television or Hi-Fi), etc.
We can also ccok more intelligently: cooking with a lid helps retain the heat and cook using three times less energy.
We have to ensure that the fridge door stays closed, not allow the freezer to fill up with ice, as that greatly reduces its efficiency.
Saving hot water is also possible, for example by filling the dishwasher or washing machine up as much as possible before using it, or even doing the washing up in a sink full of hot water instead of under a running tap. Take showers rather than baths is also four times less expensive (as long as you don't stay for hours in the shower, of course…).
Using energy saving light bulbs, which consume less and last longer, or even choosing lampshades which are a light colour and which allow more light to pass and reduce lighting costs.
But we an also try to make the most of free energy provided by the sun for lighting the house, by opening the curtains in the morning instead of switching on the lights, or by placing your desk next to the window so you don't have to put the light on when you do your homework.
All of these little savings are an initial step in a more intelligent use of our energy.

For heating: it is also possible to make big savings by taking care about how we use the heat for the house, which accounts for nearly half of the energy used in the average Belgian home. It is for example pointless to heat the house more than 16°C when it is unoccupied, or to heat it too much, during the night or the day.

Keeping as much heat as possible in the home is very important. Close curtains and blinds at night to prevent excessive heat loss through the windows, for example.
We also have to take care not to place anything in front of radiators: no curtains (its better to tuck them behind), nor furniture, which retains the heat and prevents it from circulating properly throughout the house.

If it is too warm in a room, it is better to open a door inside or switch off a radiator as long as is necessary, rather than opening a window.
Here also, it is intelligent to make the most of the free energy from the sun, by allowing it to enter the house as much as possible.

At school also, the same things apply. Check that you switch off lights in the classroom at playtime, or switch off the toilet lights when no one is there. Heating can also be reduced at night, as there is no point in heating empty rooms excessively. Think about checking the radiators before leaving the classroom. Also think about making the most of sunlight for lighting.

For transport: it is also possible to save the energy which we use for transport purposes. We can always begin by choosing to cycle or walk for small daily journeys. Going to school by car is not always necessary and furthermore, a short walk in the fresh air is good for your health.

We can also take part in what is known as "car sharing": if several people who live in the same region go to the same place, they can always use the same car instead of using several cars. Why not think about taking a neighbour who goes to the same school as you?

There is also the possibility of using public transport more generally: this enables many people to travel and emits less polluting gases into our atmosphere.

The use of renewable energies

One of the solutions which can be used to resolve energy problems is the use of clean sources of energies which are not used up: renewable energy sources.

What is renewable energy? This is a source of energy which is not reduced when it is used: when I use a renewable source of energy, I do not prevent other people from using it also. Furthermore, resources are constantly being renewed, so there is therefore no risk of them running out.
These are two of the major characteristics of renewable energies, which bring into play different aspects. Indeed, at present, I am not preventing anyone from using energy when I use a renewable source of energy. Placing a solar panel on my roof does not prevent anyone else from using solar energy for their home. On the contrary, when I burn oil, I prevent someone else from making use of it. The second aspect is the future: when I use renewable energies, I do not prevent anyone from using these same sources of energy in the future. Operating a wind turbine now will not mean that there will be less wind tomorrow. Here again, the opposite applies with fossil energies, whose resources diminish endlessly…

Let's not lose sight of the fact that it must be possible to use energy. To do this, as we have seen at the start of this text, we need machines which enable us to transform the source of energy into a useful form of energy. Current technologies have made great progress in this area.

What are these sources? They are the sun, the wind, but also rivers, tides, heat from the environment (the ground – we speak here of geothermal energy, air and water) and organic matter (biomass) such as wood and plants.

A short history

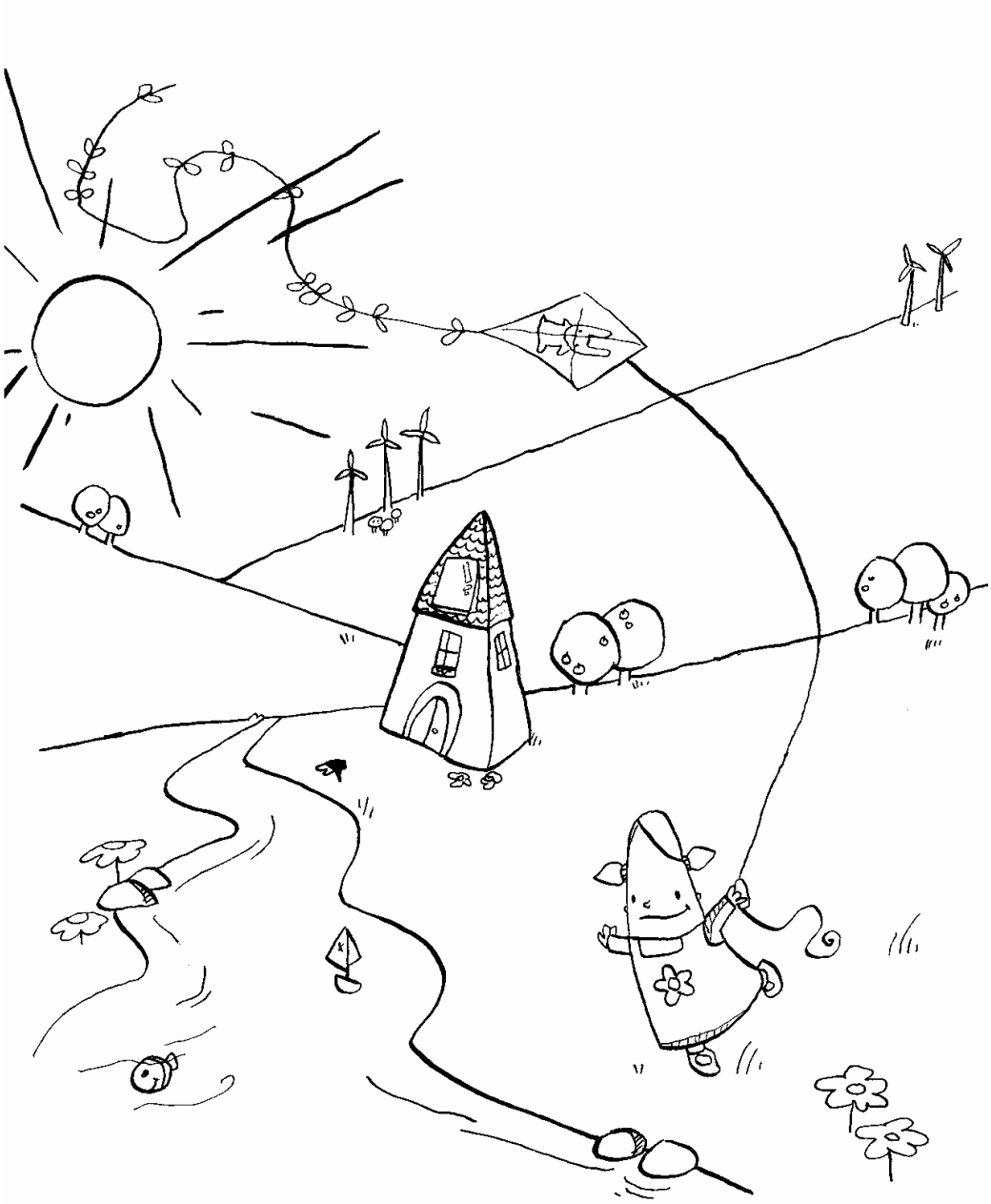
Renewable energies are not a recent invention: they have been used by humans for all time, in the way which they built, for example. Here are a few examples:
The sun enables us to obtain heat by building hoses which are suited to make the best use of light. The proper orientation of the house enables the most light to enter it, and well insulated walls retain the heat inside the house for as long as possible.
Rivers are used to transport heavy loads over long distances, as well as to provide the energy required to mill grain in watermills.

Mills make it possible to benefit from wind energy to help men in their daily tasks. The wind has taken numerous sailing ships across the seas and oceans everywhere in the world.

The discovery of coal and other fossil energies greatly increased mankind's energy requirements. The discovery of electricity has also increased our standard of living. Needs have therefore increased greatly over the past two centuries. The easiness of using fossil energies has resulted in us forgetting about renewable energies, which we believe are incapable of meeting our requirements.

But recent technologies have increased the efficiency of machines which use renewable energy sources. It is now possible to produce a lot more energy using renewable sources than a century ago. We are now even capable of producing electricity with the sun or the wind, which was inconceivable in the last century.

If we add to this the extensive damage caused to our planet through the massive use of fossil energies, we can understand why renewable energy is once again starting to become popular.

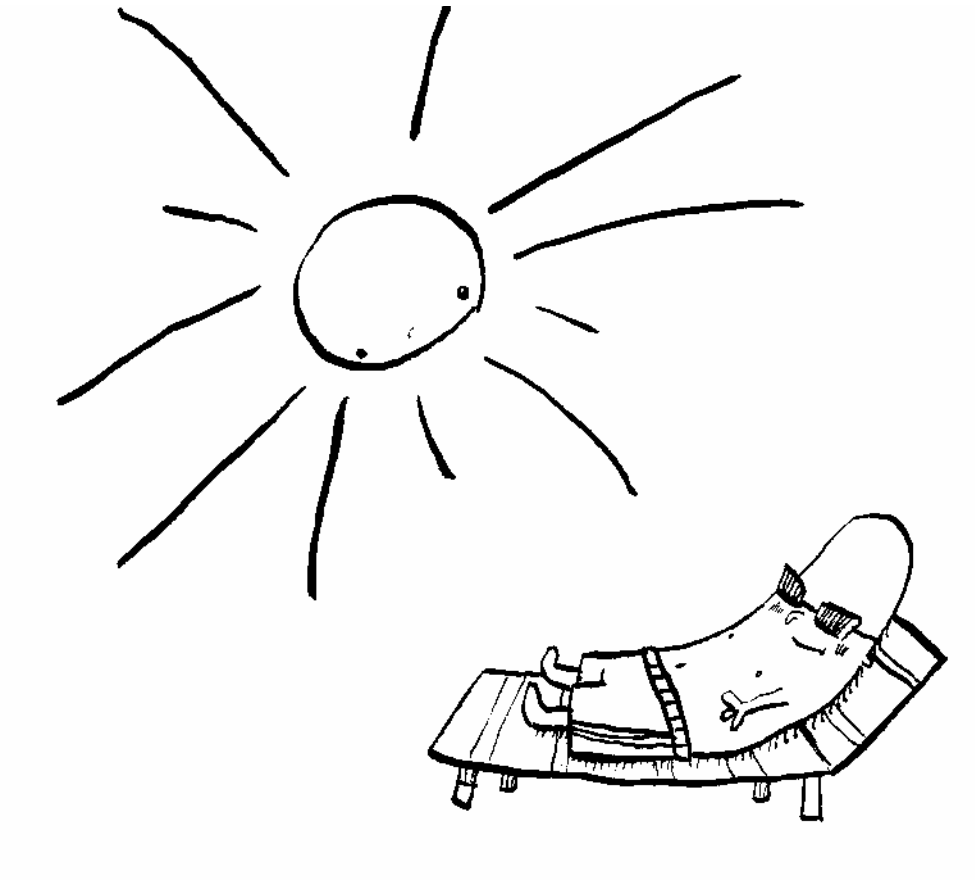


Renewable energies today

The most important source of renewable energy is the sun: this sends an enormous quantity of energy to the earth in the form of light. This light can be used to heat matter: we then take advantage of free heat. We shall explain in detail further on how a solar panel is used to heat water.

But by using the appropriate materials, we can use this energy to produce electricity (we call this technology "photovoltaic energy", "photo" which comes from the Greek for light and "voltaic" as in volts, the unit de of measure for electrical currents). The sun's rays provide energy in the solar panel, which generates an electrical current. This can

be used directly or can be used to charge batteries or accumulators, such as those found in mobile phones, for example.



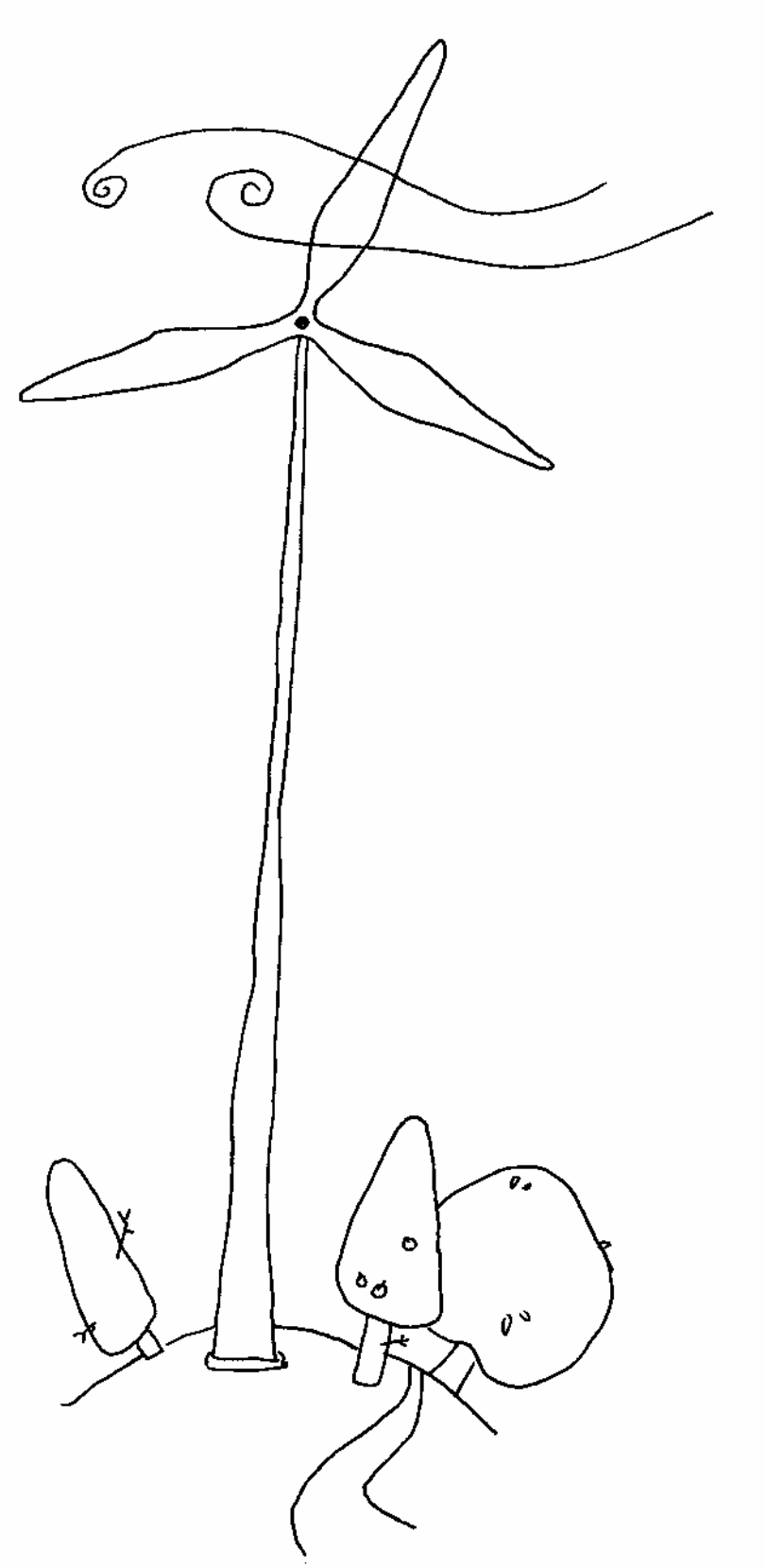
But the sun is then used in many other ways. Indeed, it heats our planet, as we have seen: this heat is not distributed equally over the earth and is responsible for the winds which blow over the Earth.

We can then use wind power to produce electricity, with the help of wind turbines. The wind moves the wind turbine's propeller which begins to turn. A generator (a sort of large dynamo) is placed behind this propeller and then produces electricity, like in a dynamo placed on a bicycle wheel which produces electricity for its lamp. We can see today that wind turbines whose mast can be 100m high, provide electricity for entire towns.

The wind also enables windmills to turn at a simpler level to raise water from the depths of the Earth. This technology is widely used in Africa, where water resources are scarce and sometimes difficult to access.

We can also use wind power in its mechanical form to mill grain.

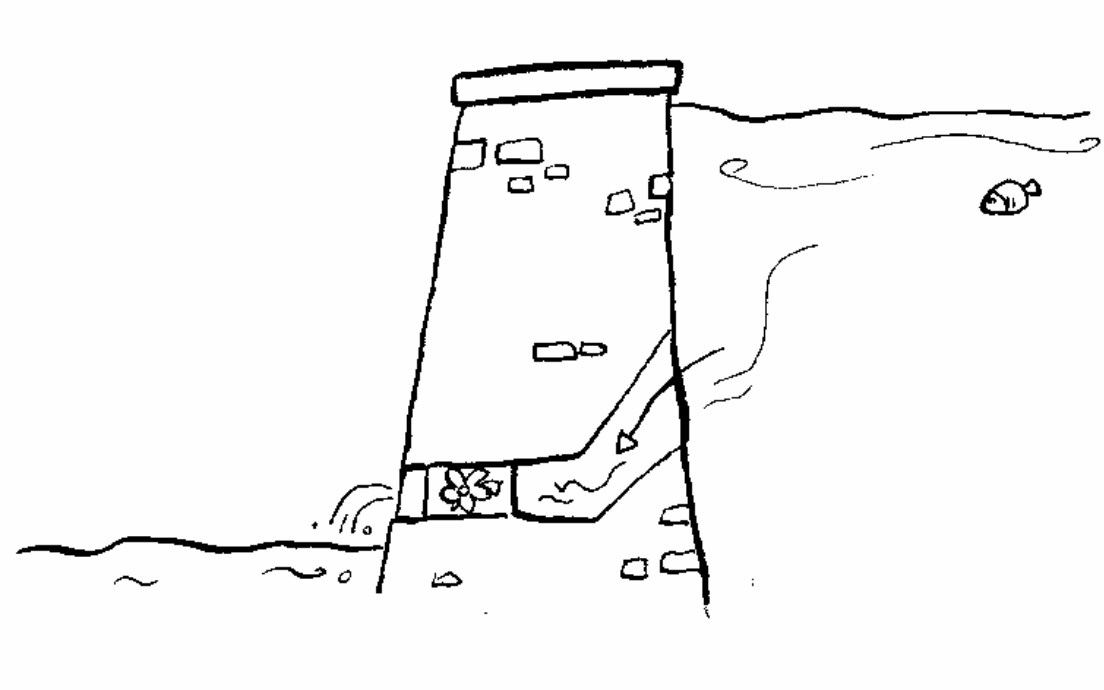
Finally, let's not forget playing, and the wind which carries our kites high into the air…



In order to live, grow up and reproduce, plants also absorb energy from the sun, through a unique phenomenon called photosynthesis.
We can then burn the wood from trees for heating or to produce steam. As long as we replant trees every time we cut some down, we also have a source of renewable energy. All waste of plant origin, bark from trees or scrap (we now speak more often of "by-products", rather than "waste", as we can use them again!) harvests, the forestry and agriculture industry, or animal waste such as horse manure, for example, decompose and then emit gases such as methane which it is possible to recover, in order to produce energy in the form of heat, electricity or even fuel. In these cases, we speak of the use of biomass. Cutting edge techniques currently enable this source of energy to be used very effectively. Certain crops such as oilseed rape and beet can be transformed into oil or fuel to run engines. In this case, we speak of biofuels.

The sun is not the only source of heat on the Earth. The Earth's core is a very hot mass, made of magma in fusion which sometimes surges up during a volcanic eruption. It is also possible to use this heat with the help of geothermal wells. We call this technique geothermal. The United States, Italy, Alsace, Iceland, Japan and New Zealand use a lot of this type of energy. With considerable natural resources, these countries make use of them to produce heat and in certain cases electricity. But we can also make use of geothermal energy on a small scale, with what are known as heat pumps. This technology enables us to save energy, but is generally not considered to be a truly renewable energy.

It is also possible to use the energy contained in moving water, such as in rivers, marine currents, waves and tides.
On rivers, electricity can be produced using hydroelectric power plants. Here also, water power simply turns a sort of huge dynamo which produces electricity. In order to be able to regulate the flow of water, we can store it in huge reservoirs or dams which also provide water for entire cities. But this is not always the case. Indeed, there are a number of power stations along a river, which divert part of the water in the river and place it back in the river lower downstream, after making use of the potential energy available. This makes it possible to use a river's energy locally, and we have seen a number of these mini-hydroelectric plants being set up, providing electricity to individuals and communities.



As we have already pointed out, the simplest and most common use of this energy has been around for a long time, to turn watermills and move ships.
But water energy is not limited to rivers: it is also possible to use the power of tides.

A short summary table

Here is a short table summarising the renewable energies which we have discovered up until now. There is more space which you can fill in, as we may have forgotten one or two…

Source of energy	Machine	Useful effect
Wind	Wind turbine	Electricity
Sun	Plants (through photosynthesis)	Respiration, life
Gas from the decomposition of plant waste	Burner	Heat
Vegetable oils	Engine	Movement
Heat from below the ground	Geothermal wells	Heat
Waterways	Hydroelectricity plants	Electricity

Thermal solar panels: a practical example

One possible use of the sun is to heat domestic water, used to wash, to do the washing up and the housework. It therefore involves taking solar energy to meet our daily hot water requirements.

How does it work? Through the greenhouse effect used properly.
We are going to try to trap the sun's energy, using this greenhouse effect, in what we call a solar panel.
This heat will then be transmitted to the domestic water.

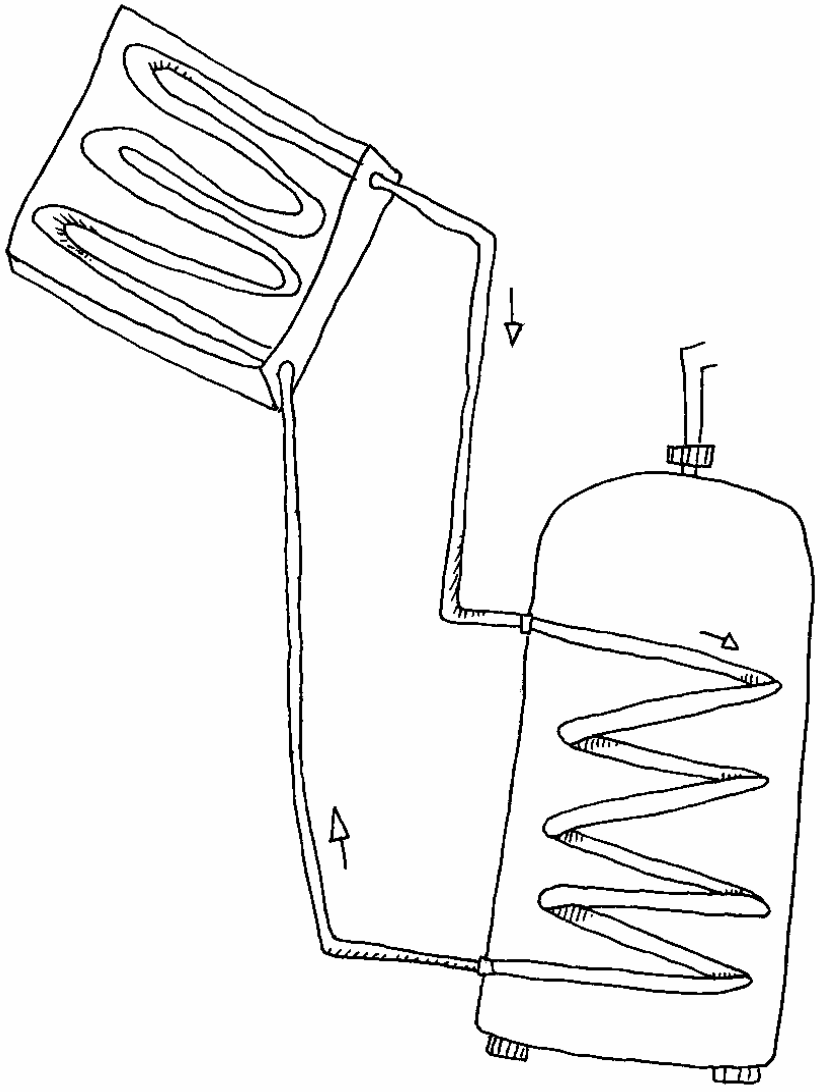
The solar water heater

As its name suggests, the solar water heater is a system which is used to produce hot water with solar energy.

Where can this be used?

- In houses and blocks of flats: to heat domestic water (for the kitchen and bathroom
- In public swimming pools, sports centres, hospitals, hotels, inns, etc.

In short, in any building where there is a regular need for hot water.



cleaning

Take the case of the domestic solar water heater.

What purpose does it serve?

Heating the domestic water used every day by the people who live in a house.

How can domestic water be heated by the sun?

- *How can domestic hot water requirements be met at all times in the house, flats, or even at the hairdresser's?*
- *When do we need hot water? For what uses?*

  Morning, noon and night, at any time during the day (or night) we want to have hot water available in our taps to be able to wash, wash up, clean, etc.

Let's watch the system: it is made up of solar panels, a storage tank, pipes, an electronic regulator and a pump or circulator.

Transforming sunlight into heat and capturing it: the role of the thermal solar panel.

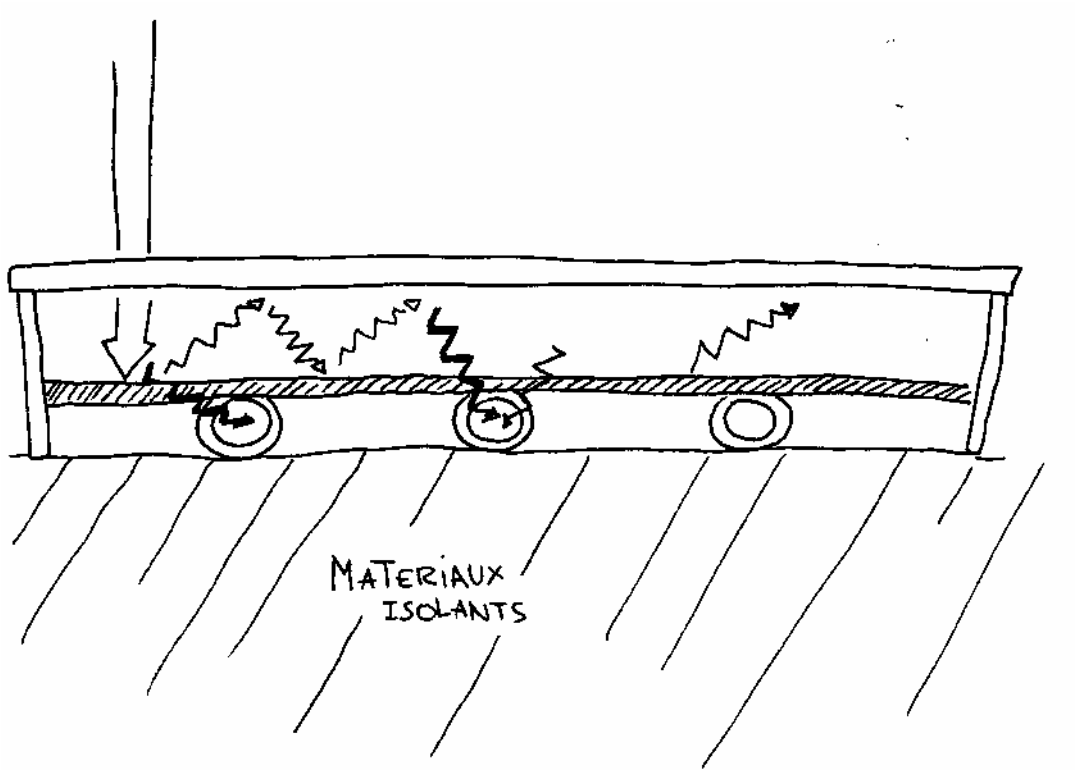
Transformation

First of all, we have to understand that it is possible to transform sunlight into heat. The principle is simple.
When sunlight hits a surface: part of this energy is reflected (the light is deflected) and part is absorbed by the surface, which is going to heat up. The lighter a surface's colour, the more it will reflect the light. The darker it is, the more it absorbs the light, and therefore it heats more under the effect of the light.
For example, snow-covered ground reflects the sunlight so well that it can even dazzle us! And to avoid getting too hot in the sun, it is better to wear light coloured clothes than to dress all in black.

The trap

Thermal solar panels are made to transform as much light as possible into heat. The heat produced inside the panel is trapped!
In a thermal solar panel, there is therefore a black metal plate. It is called the absorber. This is placed in a glass case which is well insulated at the back and on the sides.
The glass allows the light to pass through it as it is transparent.
The black plate, the absorber, absorbs light and heats up under the effect of being exposed to the sunlight.
The glass prevents the heat from escaping from above. The greenhouse effect is achieved.
The insulation placed behind the absorber and on the sides of the case prevents the heat from escaping at the back and on the sides.
Through the glass and the insulation, the heat is trapped inside the case. It therefore gets very hot inside the solar panel.

Using a shoebox, a transparent film, a black plate and a small quantity of insulation, it is therefore possible to transform sunlight into heat and trap it in the box. Try it for yourself! It's going to heat up! This is the same principle as for solar cookers, where you simply have to place a good meal inside the box for it to cook or reheat.



[insulating material]

Transferring energy and storing it: the roles of the circuit of pipes (primary circuit), the pump or circulator, the electronic regulation and the storage tank

With all of this equipment, we haven't yet got hot water in our tap!
Now we have managed to create heat, and this heat has been captured in the panel, on the roof of the building. We are therefore going to have to retrieve it and bring it to where it is needed.
We not only need to bring this heat inside the house, but we also have to be sure that we can use it at any time! Not only at midday!
We can guess the times when the panel is going to be the most effective: when it is light, so never during the night!
In the house, the hot water is either drawn from a hot water tank, or it is heated instantly if it is equipped with an instant gas heater.
In order to be able to use solar energy night and day, we are obliged to store the energy. We therefore use the principle of the hot water tank.

Transferring the heat to the tank

Copper pipes are welded to the back of the absorber. This metal is a good heat conductor. By circulating a liquid in the pipes welded to the hot absorber, the liquid also becomes hot. We are therefore going to make the most of this effect and use the liquid to transport the heat. The role of the liquid in the system is to take the heat from the panel to the tank. The liquid used to transfer the heat (water and antifreeze and antioxidant) circulates in a closed circuit, which is fitted between the panel and the tank.

Is there a pilot in the system? Who runs it?

As in any vehicle, the heat-carrying liquid also requires energy to circulate. The pump or circulator plays the same role as the engine in a car. In order to operate, the pump or circulator also requires energy, they run on electricity.
Electronic regulation to control when the system starts up and stops.
Note that the vehicle can not decide for itself. It has to receive instructions to know when and how fast it has to move and when it has to stop. For example, at night, it can never operate. It is shut down as the panel does not produce heat during the night.
It is therefore an "automatic pilot", an electronic regulator, which controls the start up and stopping of the system. By receiving a little, simple information (temperature data), the electronic regulator controls the stop / start actions.

Starting up the circulator

The electronic regulator decides to start up the system when it is worthwhile, that's to say when there is heat to be transferred from the panel (a small temperature sensor is placed in the panel and is connected to the electronic regulator), and that the tank needs it to be at the right temperature (for example 50°C, there is also a thermometer in the tank which is connected to the electronic regulator).

Stopping the circulator

The electronic regulator decides to stop when the tank is at the right temperature and at any moment when there is too little heat in the panel (always at night), or when the panel temperature is lower than the tank temperature (in these cases, if we did not stop the system, it would cool down the tank!).

A tank which stores heat

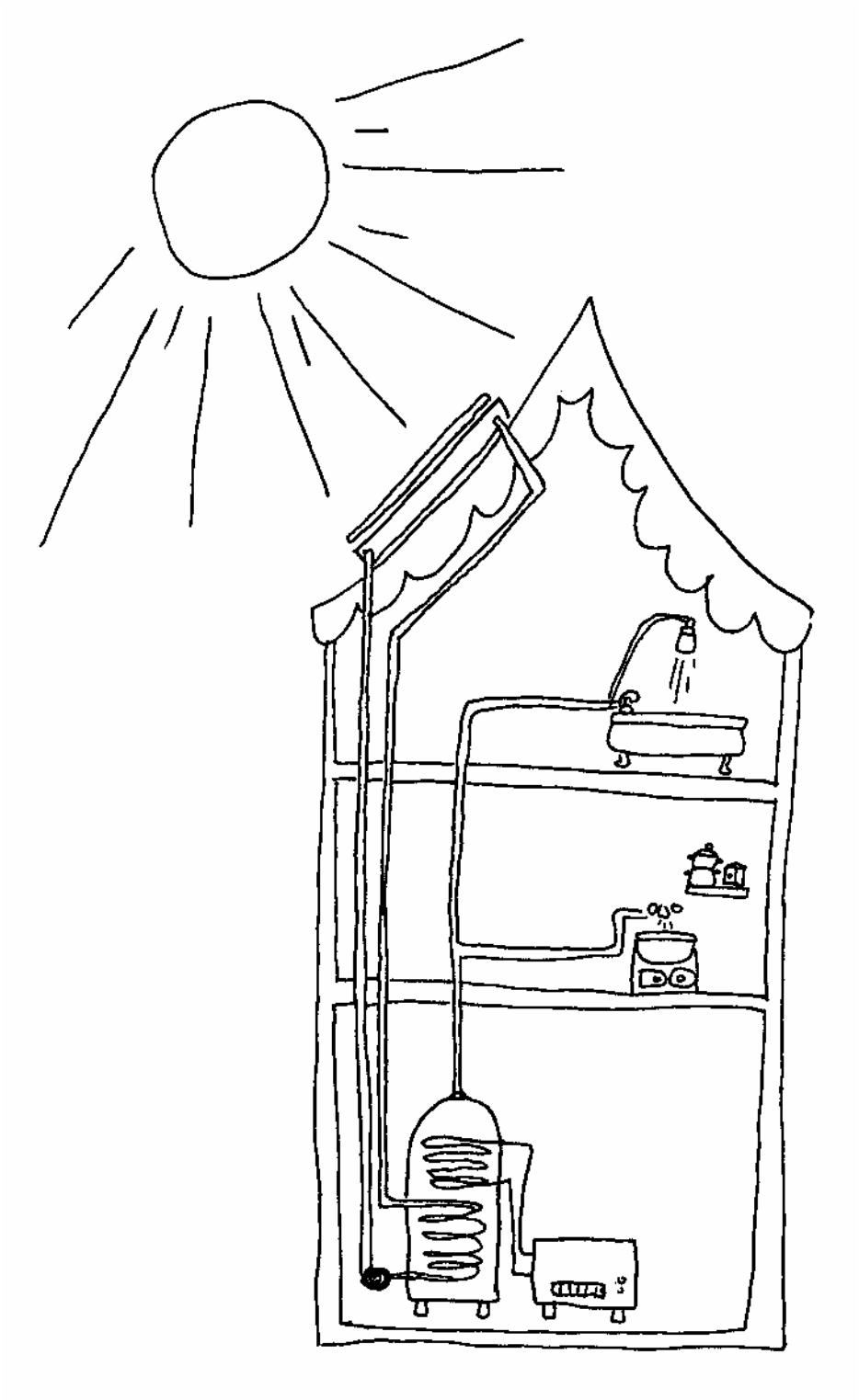
The work of solar water heater installers is not only to go and place solar panels on the roofs of buildings. It also involves first of all finding out as accurately as possible the quantities of hot water that a family normally uses each day, in order to correctly estimate the quantity of hot water to be stored in the tank.
You could do this yourself at home: how many baths, showers and sinks of hot water are filled for the washing up each day, how many buckets filled for cleaning, etc. how many litres of water does that add up to each day?

When we know this information, we can determine whether it is better to install three, four, five or six square metres of panels on the roof. For it is not worth installing ten square metres if you only need five. Indeed, half the time, especially in the summer, the heat will be produced for nothing, and will not be used by anyone.
And in the depths of winter, when there is too little light to heat the domestic water, there is generally also not enough light o operate five, ten or twenty square metres of panels! (we could illustrate this with the reminder that 5x0 = 10x0 = 20x0 = 0!)

Standard kits for single family home
For a volume of 200 litres, we install 4 m2, for 250 litres 5 m2, for 300 litres, 6 m2, etc.

The solar water heater is combined with other traditional sources of energy to generate hot water throughout the year.

In our climate, our buildings have to be heated throughout the winter.
In this season, the days are too short to collect all the solar energy required for all the heating in our buildings.
So in winter, the solar panels provide what they can and most of the heat is supplied by the traditional boiler which operates in any case to heat the house. This is far more practical and cheaper.
When necessary, the solar panels are therefore connected to the water heater automatically. Thermometers are placed in the hot water tank and in the panels. If the temperature of the hot water in the tank falls and the temperature in the panels is even lower, the hot water tank is heated using energy from the boiler.
We do not expect the solar panel to be capable of heating all the water needed every day throughout the year. What is expected, in order to save money, is instead to heat around half (50 to 60%) of the quantity of water consumed throughout the year.
The solar water heater therefore greatly reduces the work of the boiler, saving electrical energy, gas or heating oil!
It therefore becomes possible to completely shut down the boiler for the entire summer and let the solar panels operate alone for an average of six months per year.
We have just explained the technology used in solar water heaters. It's as simple as that.



Millions of thermal solar panels have already been installed throughout the world. They enable real energy savings to be generated whilst maintaining the current level of comfort. The Walloon Region is planning to install this system in 50,000 homes, that's to say 200,000m² of solar panels between now and 2010.

A solution for developing countries

Renewable energies are also a source of hope for developing countries. These countries are generally not rich enough to purchase fossil fuels. But renewable energy sources enable them to make the most of energy with no major financial investment.
Wind turbines make it possible to provide electricity to extremely remote villages. Making the most of the sun's energy is also very easy in countries where there is more sun than in Belgium.

All of these possibilities should by explored in order to make our world fairer without destroying the planet with polluting, dangerous gases. Each case has to be examined individually, depending on local conditions, as renewable energies can not be relocated easily. For example, we would only be able to use the energy from water if there is a river nearby. The same goes for wind energy: we have to find places where the wind blows sufficiently in order to install wind turbines. But in spite of all these restrictions, renewable sources of energies offer great promise for humanity.

Conclusion

Face with the problem of energy, the exhaustion of fossil fuel resources and climate change, no one can remain unmoved. But the important thing is to be able to act and react! We have looked for possible solutions together, which can be applied straight away, starting with what each one of us can do at home without costing anything, except by changing a few bad habits, to save energy.
The ongoing effort to prevent waste is the first, most intelligent and most valuable action that we can all do.
Then if we bear in mind that certain machines use up more energy than others, when we use them or when we are confronted with a new purchase – from a light bulb to a car, not to mention games or domestic appliances, we can act and choose in full knowledge of the facts.
Technologies which use renewable energies are not science fiction. They hold no secrets. People have been using them for thousands of years. As we have seen in detail with the solar water heaters, the basic principles for using them are simple. Renewable energies are therefore available today, with their old and new technologies, with their advantages and limitations, with a whole series of possible combinations, to offer a response to current energy issues.
To reduce our greenhouse gas emissions and pressure on fossil fuels, it is therefore imperative to reduce our demand for energy, to attempt to consume less energy and alongside this, to make an even greater place for renewable energies.

We hope that this presentation material has enabled its readers, teacher and through them their pupils, to gain an awareness of the numerous dimensions of the issues involved in energy in order to realise that ultimately, we are all responsible and can all contribute to change.

To find out more:

On the sharing of natural resources:

- Natural resources and sustainable development: www.worldbank.org/energy
- Centre for energy research: www.ecn.nl/main.html
- United Nations Development Fund: www.undp.org/seed/energy
- World resources institute: www.wri.org

On the greenhouse effect on the earth:

- Press agency specialising in the environment: www.aed-dmf.com
- United Nations Convention on climate change: www.unfccc.int
- Environmental news network: www.enn.com
- Intergovernmental group on the evolution of the climate (GIEC): www.ipcc.ch
- United Nations Environment Programme (PNUE): www.unep.org

On pollution:

- Greenpeace: www.greenpeace.fr
- Agency for the environment and controlling energy (ADEME): www.ademe.fr
- WWF international: www.panda.org/toxics
- United Nations Environment Programme (PNUE): www.unep.org

On renewable energies:

- Association for the Promotion of Renewable Energies (APERe): www.apere.org

On energy in Wallonia:

- Walloon Region, energy division: http://energie.wallonnie.be

Elements for Energy education

This (non exhaustive) reference sheet is regularly updated. To see the latest version, visit the APERe website www.apere.org .

A few tools

- **L'énergie expliquée aux enfants**
  Physical and chemical aspects, as well as environmental, strategic, economic and ethical issues, this short publication provides answers to the main questions which pupils ask (*10-14 years*) and (*above all!*) those who teach about energy.

  L'énergie expliquée aux enfants
  E. Luyckx – Editions de la CCI, 2004
  ISBN 2-930287-43-8
  Distributed by
  Ministry of the Walloon Region
  Energy Division
  Tel: 081 335 640
  E-mail: energie@mrw.wallonie.be

- **Energy à petits pas**
  A publication on the same subject in the "A petits pas" collection from Actes Sud. A children's book which is very attractively and humorously illustrated. (*from 9 years*)

  Energy à petits pas
  F. Michel – Acters Sud, 2003
  ISBN 2-7427-4543-2

- **Energy de notre planète bleue**
  Teaching pack on the subject of energy: consumption, the consequence of thoughtless consumption on the environment and natural resources. Emphasis is also placed on North/South disparities. Includes information sheets, activity files and documents for pupils. (*12-15 years)*

  ORCADES
  Tel: +33 (0)5 49 41 49 11
  E-mail: orcades@orcades.org
  12, rue des Carmélites
  F 86000 Poitiers

- **Energy**
  Teaching kit which explores the concept of energy through a barrel of oil (*presents objects which, through analogy and games, make it possible to understand history, uses and technologies related to energy*) and a battery (*illustrates, through assemblies and experiments, the electricity network, from production to consumption*).

  CSTI Nord Pas-de-Calais
  Tel: +33 (0)3 20 91 06 60
  Fax: +33 (0)3 20 91 92 32

75, chaussée de l'Hôtel de Ville
F 59650 Villeneuve d'Ascq

- **Les sentiers de energy – Itinéraire pratique de réalisations en région wallonne**
  A small booklet published by the Ministry of the Walloon Region which gives examples of achievements in the various renewable energy networks or in rational energy use.

  Ministry of the Walloon Region
  Energy Division
  Tel: 081 335 640
  E-mail: energie@mrw.wallonie.be

- **Les énergies renouvelables au bout des doigts**
  This teaching booklet presents all of the technical and teaching information sheets required by teachers and other presenters to conduct presentations in the context of teaching projects aimed notably at adolescents (ISBN 2-9516338-0-7). An experiment kit has been designed to accompany the booklet, which makes it possible to carry out experiments and the practical demonstrations described.
  Based on project education, this tool has been designed by ASSEM, the Provence-Alpes-Côte d'Azur regional delegation of the Association Nationale Sciences et Techniques Jeunesse, in partnership with other associations.

  ASSEM stj
  Erwan Le Duff
  Tel: +33 (0)4 92 60 78 78
  E-mail: assemstj@wanadoo.fr
  9, rue Gazan
  F 06130 Grasse

- **Les énergies renouvelables**
  Another teaching kit, resulting from the experience acquired through 300 presentations to classes in Alsace between 1995 and 2000. If you only have one day or the entire school year to devote to the theme of energy, this kit includes a teaching guide with various types of fact sheets and a game, a series of slides, material for experiments, a document on renewable energies and experiment sheets for pupils.

  Alter Alsace Energies
  Laurent Atienza
  Tel: +33 (0)3 89 50 06 20
  E-mail: info@alteralsace.org
  4, rue Foch
  F 68460 Lutterbach

- **Solix, enquête sur les énergies renouvelables**
  A comic book which humorously describes the adventures of Solix as he discovers renewable energies on Earth. (*7 – 11 years)*

  Association Energies Solaires Développement
  Tel: + 33/ 0561 39 83 23
  E-mail: energiesoler@wanadoo.fr
  Rue des Arts, BP 127
  F 31676 Labège Cedex

- **HELIOMOBILE - Soltherm**

  Presentations to raise awareness on solar energy conducted by specialist presenters using a solar water heater mounted for demonstration purposes on a trailer. These presentations are aimed at primary (5th and 6th year) and secondary school pupils (education courses through the technology and heating/plumbing sections of technical/professional education).

APERe asbl (see the section "Actors in French-speaking Belgium") –Héliomobile information
Kim Vanguers

Actors in French-speaking Belgium

- **APERe asbl** - Kim Vanguers
  Raising the awareness of the general public on the issues surrounding energy and climate change, taking a combined approach to examine energy, the environment and society.
  http://www.apere.org
  Tel: 02 209 04 06 e-mail: educ@apere.org
  Rue de la Révolution, 7 – 1000 Brussels
- **Académie du vent –** Bernard Delville
  Amusing presentations on wind and other sources of renewable energy.
  Tel: 082 744 584 e-mail: artech@skynet.be; vents-houyet@skynet.be
  Rue du Monument, 1 – 5560 Mesnil-Eglise
- **Ateliers de la rue Voot –** Jean Mottlo
  Presentations, short courses and evening classes. Construction and installation of your own solar energy systems.
  ateliers.voot@easynet.be
  Tel: 02 762 48 93
  Rue Voot, 91 – 1200 Brussels
- **Bon…Jour Sourire** – Guerrino Barp
  Training courses, Presentations, Speeches.
  g.barp@euronet.be
  Tel: 085 41 12 03
  Gd Taillis, 11 – 4560 Pailhe
- **Centre Urbain – ABEA (Brussels Energy Agency)**
  www.curbain.be
  Tel: 02 219 40 60 e-mail: www.curbain.be
  Boulevard Anspach, 59 – 1000 Brussels
- **CIFFUL – Interdisciplinary Training Centre for Trainers at the University of Liège**
  Teaching packs on energy use.
  Tel: 04 366 22 68
  Sart Tilman B5 – 4000 Liège
- **COREN**
  Information and raising awareness on environmental management.
  Campaigns, presentations and energy audits aimed at primary and secondary schools. Teaching packs.
  http://www.ful.ac.be/hotes/coren
  Tel: 02 640 53 23 e-mail: coren@skynet.be
  Rue Van Elewijck, 35 - 1050 Brussels
- Les **CRIE** (Regional Environmental Initiative Centres)
  The CRIE at Mariemont (Tel: 064 238 010; Fax: 064 238 019) presents an exhibition with models for each of the RE networks.
  mrw.wallonie.be/dgrne/education/crie
- **DGTRE** of the **Ministry of the Walloon Region** (General Division for Technologies, Research and Energy)
  www.energie.wallonie.be
  Tel: 081 33 55 06
- **Environnement et Découvertes** - Vincent Cappeliez
  Presentations, exhibition, giant games
  www.environnement-et-decouvertes.org
  Tel: 065 840 280 e-mail: edasbl@tvcablenet.be
  Rue des Robiniers, 63 – 7024 Ciply
- **Fondation Polaire Internationale**
  Presentations, teaching packs
  www.educapoles.org

e-mail: l.dubois@educapoles.org

- **IBGE** (Brussels Institute for Environmental Management)
  For all information about environmental management in the Brussels Region
  www.ibgebim.be
  Tel: 02 775 75 75 e-mail: info@ibgebim.be

- **Institut d'Eco-Pédagogie**
  Raising awareness and training adults on environmental education.
  Assistance with projects, research, publication, organisation of events and expert teaching advice.
  www.ful.ac.be/hotes/iep/
  Tel: 04 366 38 18 e-mail: ee-iep@guest.ulg.ac.be
  Sart Tilman B22 – 4000 Liège

- **Réseau IDéE** (Information and Diffusion of Environmental Education)
  Network of associations and institutions operating in ErE (education related to the environment)
  Publishes the quarterly magazine Symbioses which includes a teaching pack with each issue.
  See the quarterly magazine Symbioses n°46: habitat écologique and references to renewable energies. See also the "Energy de notre planète bleue" pack (10-14 years – 1994)
  www.reseau-idee.be
  Tel: 02 286 95 70 e-mail: info@reseau-idee.be
  Rue Royale, 266 – 1210 Brussels

- **WWF –Education service**
  Campaign, packs and teaching tools available for sale or hire
  www.wwf.be
  Tel: 02 340 09 92 e-mail: info@wwf.be
  Boulevard Emile Jacqmain 90 – 1000 Brussels

Actors outside Belgium

- **Association Energies Solaires Développement**
  Controlling energy and renewable energies.
  A mobile multi-energy platform using experiments helps understand about renewable energies.
  BP 127 – Rue des Arts – F 31676 Labège Cedex
  Tel: + 33/ 0561 39 83 23 e-mail: energiesoler@wanadoo.fr

- **Fondation Nicolas Hulot**
  Proposes introductory texts, packs, education actions for presentations and, last but not least, a directory of teaching tools.
  Contact in Belgium:
  Assocation Nicolas Hulot
  Tel & Fax: 087 229 657 e-mail: anhb@swing.be
  Avenue Jean Tasté, 78 - 4802 Heusy

- **Centre écologique Terre Vivante**
  See the "School visits or trips" section
  http://www.terrevivante.org
  Tel: + 33/ 04 76 34 80 80 Fax: + 33/ 04 76 34 84 02
  Domaine de Raud - BP 120 - F 38711 Mens cedex

- **Centre for Sustainable Energy**
  Information
  http://www.cse.org.uk
  Create Centre
  Tel: +44/ 117/ 929 9950 e-mail: info@cse.org.uk
  Smeaton Road – UK Bristol BS1 6XN

- **Centre for Alternative Technology**
  Demonstration Centre (see the "School visits or trips" section)
  http://www.cat.org.uk
  Education department
  Tel: +44/ 1654/ 705981 Fax: +44/ 1654/ 703605
  Machynlleth
  Powys – SY20 9AZ UK

Internet links

Apart from the websites of the organisations mentioned, here are a few sites which offer interesting tools which are directly related to the subject of energy or similar issues.

http://www.fnh.org/francais/doc/en_ligne/energie/intro.htm, "énergie" pages from the Fondation Nicolas Hulot pour la Nature et l'Homme website; contains a directory, classed by age, of teaching tools available in France.

http://000999.crdp.ac-caen.fr/energies/introduction.htm, very good *Themadoc* information pack on renewable energies; *14 - 16 years*

http://perso.wanadoo.fr/galian.f/, instructions on how to make small demonstration models: wind turbine, Stirling engine; *14 - 16 years*

http://www.windpower.org/fr/kids/, the adventures of Moulinot: all about wind energy, *12 - 14 years*

http://www.apere.org

http://www.rac-f.org/rubrique.php3?id_rubrique=70, to calculate CO_2 emissions.

http://www.rinky-dink.org

http://www.schoolenergy.org.uk/home

http://www.eia.doe.gov/kids/links

http://www.school4energy.net

http://www.solarpartners.org/default

http://www.solideas.com/solrcell/cellkit

http://www.kweevak.com/solarcd

School visits or trips

- The sites listed in the "Sentiers de energy" brochure, published by the Walloon Region. Available from the Information and Assistance Centres in the Walloon Region or by order from the "Energie" website (http://energie.wallonie.be).
- The circuit organised by the Nature et Technique association (Tel. 087/765 009; Fax 087/765 009). Three-hour coach trip during which we discover solar energy (photovoltaic), wind energy, waste water treatment and biogas production, energy saving in the home (green roofs and passive solar energy).
- The Terre Vivante ecology centre, near Grenoble in the South of France. Enables you to see and experience a number of means and actions aimed at protecting the environment. It offers two exhibitions in particular: "La maison des négawatts", that's to say a house which is as comfortable as any other but uses far less energy[1], and an exhibition on heating with wood.

  (See details in the "Actors outside Belgium" section)
- The Centre for Alternative Technology offers a series of methods and actions, in real operating conditions, aimed at protecting the environment. It is set in a superb region in West Wales. (See details in the "Actors outside Belgium" section)

Material to build mini solar or wind turbine systems

- OPITEC Belgie BVBA
  www.opitec.be
  Tel: 03/234 36 13 - Fax: 03/234 30 18 e-mail: info.nl@opitec.com
  Boomsesteenweg, 690 - 2610 Wilrijk

[1] Also available in a mobile version (for more information, contact Christine Corbet).

Appendices

Appendix 1: The operating principle of an electricity generating plant.

The general operating principle of an electricity generating plant is not in fact very complicated to understand: it is mainly a large steam engine connected to a sort of large bicycle dynamo!

Let me explain… The dynamo on your bicycle makes it possible to generate electricity through the movement of the wheel. In a power plant, the same thing happens (more or less). To generate electricity, a large generator or alternator is turned, which produces electricity. Its principle is complicated, and we shall not go into the details. All you have to know is that the aim of this machine is to transform movement into electricity.

But then, you will tell me, the generator has to be turned! That's quite right. And what makes this generator turn depends on the type of power station.

In a hydroelectric plant, water power is used directly to make it turn. In wind turbines, it is the wind. In combustion plants, wood, coal, oil or natural gas are burned in order to heat a large quantity of water. This hot water is going to boil and turn into steam. The power of this steam is then used to turn the generator, just like a steam engine!

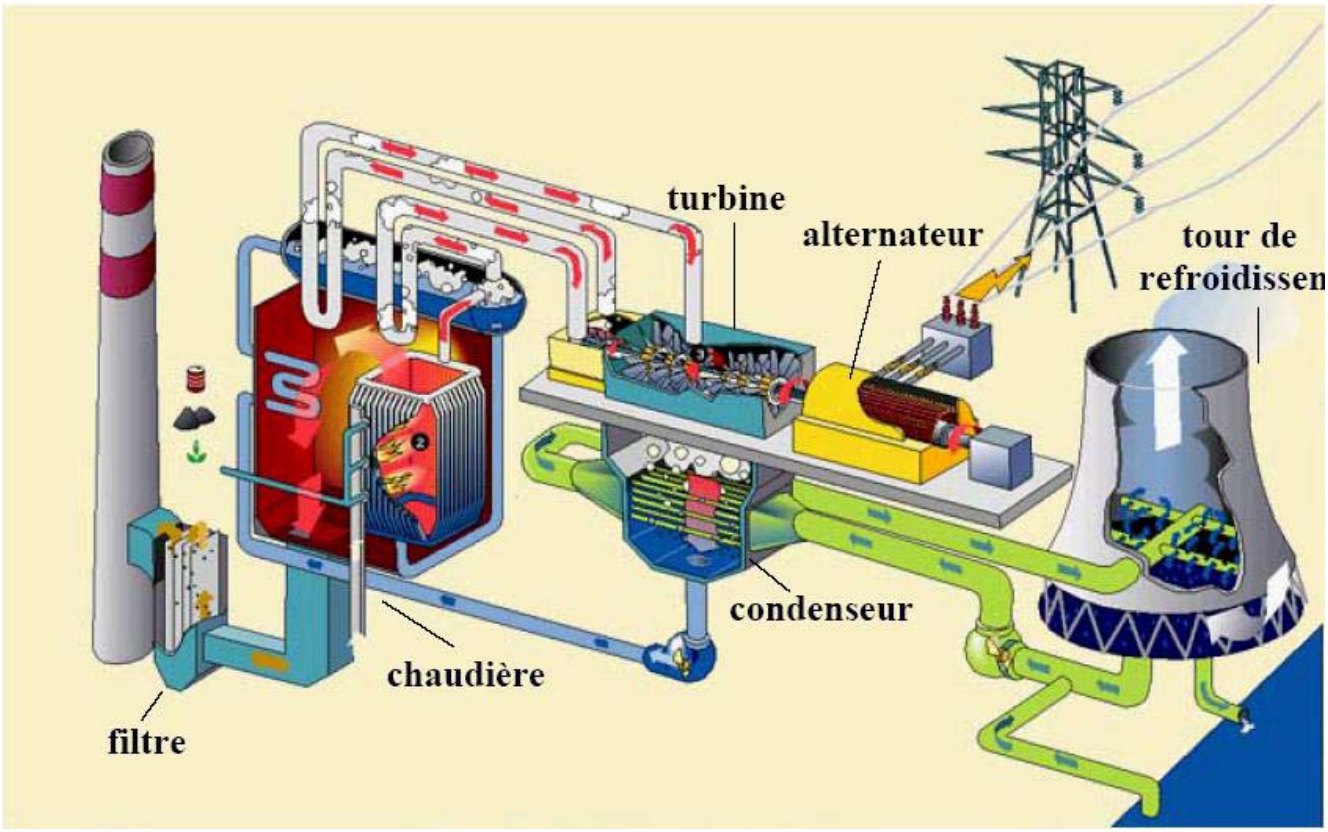
Here is a small diagram of a combustion electricity generating plant to help you understand.

The most important part of the plant is the boiler: combustible material is burned to generate heat. The smoke is recovered and cleaned in the filter.

This boiler heats a large quantity of water, which then boils and turns into steam. This steam is channelled into a large turbine, which starts to turn. This turbine is connected by means of a metal axel to an alternator, which is a generator that produces alternating current. It is this current which is then distributed through the grid to which we are connected.

The steam is then cooled to become water again. This takes place in the condenser. It is called a condenser because it condenses the steam into liquid.

In order to cool this steam, we generally use water from a nearby river. This water is going to be heated up by the heat from the steam, and will have to be left to cool down. It is then sent into the river.



Source: Electrabel
[turbine – alternator – cooling tower – filter – boiler – condenser]

Appendix 2: Short glossary

Machine: we have used the word "machine" to refer to what transforms a source of energy into a useful effect. This is a rather specific usage of the word, as we can then say that the human body is a machine, as it transforms the energy found in food into movement, thought, growth, etc.

Electromagnetic waves: the term "electromagnetic waves" in fact covers all of a particular type of rays, which have no mass. Light is an electromagnetic wave, just like X-rays, ultraviolet rays, infrared rays, etc.

Photosynthesis: this word is used to designate the process by which plants respire and grow. Plants take energy from sunlight in order to transform the carbon dioxide in the air into oxygen (which it rejects into the air) and the carbon which they need to grow. This is a process used by all green plants.

Combustion: combustion is quite simply the fact of burning something. When we burn an object, we cause a chemical reaction, between the object and the oxygen in the air. This reaction always produces carbon dioxide.

Nuclear power stations: this is quite simply an electricity generating plant which uses uranium 235 as a fuel, a highly dangerous substance: it is said to be "radioactive" as it emits many dangerous rays.

Hydroelectric power stations: These are electricity generating plants which use power from a river to produce electricity.